ASSESSMENT AND PRIORITIZATION OF STREAMS IN UPPER POCOMOKE, WESTERN BRANCH, PISCATAWAY CREEK, OXON CREEK, PATUXENT RIVER MIDDLE, AND BALTIMORE HARBOR WATERSHEDS IN NEED OF RESTORATION AND PROTECTION

CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT

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Final Data Report:

Assessment and Prioritization of Streams in the Upper Pocomoke, Western Branch, Piscataway Creek, Oxon Creek, Patuxent River Middle, and Baltimore Harbor Watersheds in Need of Restoration and Protection

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Introduction

This work was completed by the Maryland Department of Natural Resources (DNR), Resource Assessment Service, Monitoring and Non-Tidal Assessment Division under award number NA17OZ1124.

In response to former President Clinton's Clean Water Action Plan, Maryland completed it's first Unified Watershed Assessment (UWA) during 1998. The UWA identified Maryland watersheds (8-digit) most in need of restoration and protection. This annual report uses results from the Maryland Biological Stream Survey (MBSS) to assist in the prioritization of specific areas within the 8-digit priority watersheds identified by the UWA. This finer scale analysis can be used to target limited funds within each watershed so that they provide the maximum benefit to stream resources. This report also provides a list of the probable stressors to biota in these specific areas. Knowledge of the stressors to a given stream system can be used to focus restoration efforts on parameters that should provide the greatest likelihood for success.

This reports covers six watersheds: Upper Pocomoke River, Baltimore Harbor, Patuxent River Middle, Western Branch, Piscataway Creek, and Oxon Creek. According to the UWA, all of these watersheds show signs of stress and have streams that are in need of restoration. They may however contain sensitive natural resources as well which are in need of protection.

The goal of this report is to provide guidance for targeting resource management initiatives within each of these UWA priority watersheds. This targeting includes the identification of areas most in need of restoration and protection as well as a diagnosis of probable stressors to ecological resources in areas where restoration is needed. Although this information pertains exclusively to ecological resources, it is hoped that it will be considered as part of a comprehensive restoration and protection plan.

Methods

A total of 276 sampling sites were used to characterize stream conditions and identify potential stressors to stream resources in the Upper Pocomoke River, Baltimore Harbor, Patuxent River Middle, Western Branch, Piscataway Creek, Oxon Creek watersheds (Figures 1-6). Fish, benthic macroinvertebrate, herpetofauna, physical habitat, chemical, and land use data were collected from a total of 145 randomly selected sampling sites as part of the Maryland Biological Stream Survey conducted by the Maryland Department of Natural Resources between 1994 and 2001. Benthic macroinvertebrate data were collected from an additional 131 non-randomly selected sites during 2001 as part of the Stream Waders volunteer monitoring program coordinated by DNR. This broad sampling density provides the opportunity for conducting overall watershed assessments. Despite this major monitoring effort, however, only 1.5 percent of the total miles of streams in these watersheds were sampled by MBSS, with an additional 1.6 percent sampled by Stream Waders volunteers. The presence of minimally degraded conditions, rare or unique resources, or severe degradation in any unsampled stream reaches cannot be ruled out. A more comprehensive survey of the streams in the watershed would be necessary to provide a complete inventory of resources and conditions. However, results of the MBSS and Stream Waders sampling efforts offer useful insights into the health of non-tidal streams in these six watersheds.

MBSS (Kazyak 2000) and Stream Waders (MDNR 2001) monitoring and assessment methods are described below:

Fish

Fish assemblage data were collected using double-pass electrofishing with direct current backpack units. Each 75 m long site was blocked at each end using 0.25 inch mesh, block nets and all available habitats were thoroughly sampled. For each pass, all captured fish were identified to species, counted, and released. Fishes were collected during summer (June - September) to avoid the effects of spring and fall spawning movements on fish assemblages and to maximize electrofishing catch efficiencies. Fish data were analyzed in terms of species richness, composition, relative abundance, and general pollution tolerance. A Fish Index of Biotic Integrity (FIBI) was also calculated (Roth et al. 1998; Roth et al. 1999). Probable stressors to the biota (fishes) at each site were diagnosed based on relationships between stressor variables and fish species presence and absence previously documented by the MBSS (Stranko et al. 2001).

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected by Stream Waders volunteers and MBSS biologists using D-frame sampling nets during spring (March-April). A 100 organism sub-sample of the benthos collected at each site was processed and identified by DNR staff for both programs. MBSS samples were identified to genus taxonomic level and Stream Waders samples were identified to family taxonomic level. These data were used to calculate a genus level and family-level benthic macroinvertebrate index of biotic integrity (BIBI) respectively for each site.

Rare, Threatened, and Endangered Taxa

Any fish species identified by DNR's Natural Heritage Division as rare, threatened, or endangered based on the official State Threatened and Endangered Species List as part of the State of Maryland Threatened and Endangered Species regulations (COMAR 08.03.08) was noted.

Water Quality

MBSS water chemistry sampling occurred during the spring of each sampling year (March - April). Water samples were analyzed for a suite of parameters which included closed pH, specific conductance, acid neutralizing capacity, dissolved organic carbon, sulfate, and nitrate.

Additional sampling of water quality occurred during the summer of each sampling year when *in situ* measurements were made concurrent with fish sampling. Prior to 2000, parameters measured included dissolved oxygen (DO), pH, conductivity, and temperature. During 2000, turbidity was added to the suite of summer sampling measurements. All measurements were taken with a Hydrolab™ multiprobe water quality meter, except for turbidity which was measured with a LaMotte™ turbidity meter. Both instruments were calibrated before sampling according to MBSS QA/QC guidelines (Kazyak 2000).

Water Temperature

Temperature loggers were placed at all MBSS sites during 2001. The loggers recorded water temperature every 15 minutes from 1 June through 1 September. Maximum temperatures over this period were reported for each site sampled during 2001, unless the temperature logger was lost or malfunctioned. Prior to 2001 only one time temperature data were taken during summer base-flow. The one-time temperature measurements are reported for sites sampled prior to 2000. Maryland freshwater streams are designated for different levels of protection from thermal impacts depending on the classification of the stream by the Maryland Department of the Environment. All streams in the watersheds discussed in this report are designated as Use Class I, which means that the temperature should not exceed 32 ^{o} C (COMAR 26.08.02).

Physical Habitat

Physical habitat assessments were conducted to evaluate habitat effects on biota. MBSS habitat assessment procedures were derived from two methods: EPA's Rapid Bioassessment Protocols (Plafkin et al. 1989), as modified by Barbour and Stribling (1991), and Ohio EPA's Qualitative Habitat Evaluation Index (Ohio EPA 1987). Several parameters (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, embeddedness, and shading) were scored based on visual observations. Bank stability was scored based on visual observations at sites sampled prior to 2000 and measurements of the amount and severity of erosion replaced the visual assessment at sites sampled after 1999.

Landscape

The landscape surrounding a watershed can have a profound influence on the physical habitat structure, chemistry, and biology of it's streams. Some potentially important landscape scale factors including watershed area, physiography, geology, and soil type were described for each watershed. These factors are important in interpreting many biological, physical, and chemical findings, other than those related to human influences on streams. An additional landscape variable (land use) is also provided and can be used to investigate influences of human activities on stream ecological resources.

Land Use

Arc View software was used to generate site-specific land use and impervious surface information for the catchment (land area draining to a stream from upstream) of each MBSS site using U.S. EPA Multi-Resolution Land Characteristic Consortium (MRLC) data. These land use data are based on Landsat ^{TM} data acquired between 1986-1993 and, as a result, ***do not reflect land use changes that have occurred since 1993***.

Quality Control/ Quality Assurance

Quality control and quality assurance procedures for this project followed the MBSS methods. These procedures have been accepted by the U.S. Environmental Protection Agency and meet all requirements as outlined in "The Guidelines and Specifications for Preparing Project Plans", EPA QAMS 005/80.

Protection and Restoration Priorities

For the purpose of this report, all of the land area draining to a site on a stream is defined as the site catchment. The physical, chemical, and biological conditions of a stream site depend on the conditions (land use and land cover) of the site catchment. Anthropogenic influences to land such as urbanization, agriculture, mining, and logging dramatically alter the ecological conditions of a stream site. All land in Maryland has been (either historically or recently) anthropogenically altered to some degree. Consequently, all streams in Maryland have also been anthropogenically altered to some degree. However, streams have been altered to lesser or greater degrees depending on the type and extent of land use alterations that have occurred in their catchments. Although the effects of historic alterations can be perpetual, in many cases, recent alterations probably affect streams more than historic alterations. The inherent ability of a stream to withstand the influence of anthropogenic alterations to the landscape is also important. Streams that presently exhibit conditions indicative of relatively minimal anthropogenic alterations are termed minimally-degraded in this report. Minimally-degraded stream conditions are often manifested as Good IBI scores (scores greater than 4.0 on a scale of 1.0-5.0 with 5.0 being the best possible score). Moderately-degraded streams typically exhibit Fair IBI scores (3.0-3.9) and degraded and severely-degraded streams typically score in the Poor (2.0-2.9) or Very Poor (1.0-1.9) range respectively.

Protection

A three tiered approach was used to prioritize land area within each of the three watershed covered by this report for protection. IBI scores and the presence of endangered species at MBSS sites were the basis for prioritizing an area for protection. Due to the influence of land use and land cover alterations on stream quality, catchments of MBSS sites with Good IBI scores (minimally-degraded conditions) were given top priority for protection. The second tier priority for protection included catchments of MBSS sites with Fair IBI scores (moderate degradation). The third, lowest, tier priority for protection includes sites that are degraded or severely degraded (Poor IBI scores).

Restoration

A similar three-tiered approach was used to prioritize stream reaches for restoration within each watershed. The top priority for restoration was designated to stream reaches in catchments that have been prioritized for protection. Since all streams in Maryland have been anthropogenically altered to some degree, stream reaches in catchments that have been prioritized for protection can also benefit from restoration. In many cases, the minimally degraded status of a site can only be maintained by improving stream conditions through restoration initiatives in its catchment. Conditions may actually improve in many minimally-degraded streams as a result of restoration initiatives in their catchments. There is also a greater potential for restoration success in minimally degraded catchments compared to severely degraded catchments because severely degraded catchments often suffer from the influence of a greater number of stressors. In addition, fewer reaches should need to be restored in minimally-degraded catchments. The second tier priority for restoration included stream reaches in catchments of MBSS sites with moderate degradation (Fair IBI scores). Finally, unless the impairment presents a human health hazard, we recommend that restoration work on the third tier (severely-degraded sites with Poor IBI scores) be deferred until stream segments in higher priority catchments are restored.

Many stream reaches in priority protection catchments also in need of restoration have already been identified by the presence of an MBSS or Stream Waders sampling site. Poor IBI scores as well as data on severe or extensive bank erosion or insufficient vegetated riparian buffers and poor physical habitat ratings are available at MBSS sites and can be used to target stream reaches in need of restoration. Poor IBI scores at Stream Waders sites can also be used to find stream reaches within priority protection catchments that may also be in need of restoration. Good IBI scores at an MBSS or Stream Waders site in a priority protection catchment indicates that restoration may not be necessary in that particular stream segment where the sampled site with the Good score is located. Neither the MBSS nor the Stream Waders program has sampled every reach of every stream in all priority protection catchments. Thorough surveys of habitat and water quality in all reaches of priority catchments are needed to find additional stream reaches where restoration may be necessary.

Potential Point Sources of Pollution

Potential sources of pollution to streams in each watershed from point sources were identified based on data from the National Pollutant Discharge Elimination System (NPDES) Program as administered by the U.S. Environmental Protection Agency (USEPA). The NPDES Program gives permits to facilities to discharge a specified amount of a pollutant into a receiving water under certain conditions. Permits are given to two types of facilities: municipal and industrial. Municipal sites are point where publicly-owned treatment works receive sewage from both residential and commercial sources. Processes at these sites often produce wastewater and sludge. Industrial sites are points that discharge wastewater from industrial facilities. Pollutants that are discharged vary widely and depend primarily on the type of industry that exists.

Good Quality or Degraded Variables
Select water quality, physical habitat, land use, and biological variables sampled at each MBSS site were listed on tables for each watershed. Cells on the tables with values indicating the presence of severe degradation were highlighted in gray. Cells with values indicating good quality (minimally degraded), rare, or unique stream resources were outlined in bold. Appendix A shows thresholds for classifying values as good quality or severely degraded.

Probable Stressors to Biota
In addition to the identification of variables that may be indicative of degradation to each site, probable stressors to fish species at MBSS sites were diagnosed based on relationships previously documented by the MBSS. This method compares a list of the fish species expected to occur at an MBSS site with the species actually collected. Specific variables with values that were outside of the tolerance range for the expected but absent species at a site were listed as probable stressors to those species at that site. Several physical, chemical and land use variables were identified as probable stressors to fishes using this approach. All possible physical and chemical conditions could not be measured at MBSS sites and many that were measured were only measured one time and may not reflect the most severe conditions for biota. Therefore, the identification of land-use stressors is directly related to sensitivity of fishes to physical and chemical conditions that are likely to be more severe than reflected by other variables as a result of the conversion of land to impervious parking lots and roads or agricultural crops and pastures. Although sampling by the MBSS includes a large number of probable stream stressors, many variables not measured by the MBSS may be influencing fishes and were not detected. Discrete, one-time sampling by the MBSS may also miss important measurements that may be acting as stressors to stream biota.

Results/Discussion

Results are presented by watershed. Maps depicting areas prioritized for restoration and protection are presented first (Figures 7-12). Possible point sources of pollution based on facilities with NPDES permits are shown on watershed maps (Figures 13-18). Tables that list select variables sampled at each site with values indicative of degradation (shaded gray) and values indicative of good quality (outlined in bold; Tables 1-6) follow the maps. Probable stressors to fishes at each site are listed in Tables 7-12. Specific locations of MBSS and Stream Waders sites with site labels are shown on maps of each watershed in Appendix B.

Baltimore Harbor

Landscape
The Baltimore Harbor watershed is located in Baltimore City, Baltimore, and Anne Arundel Counties, Maryland, and encompasses 55,369 land acres. It is located within the Piedmont and Coastal Plain physiographic provinces. The primary geologic strata in the area consist of unconsolidated mud, clay, quartz, silt, sand, and gravel, along with weathered risidium from which iron and carbonate have been removed. These rock types tend to provide little acid-neutralizing

capacity (McCartan et. al. 1998). Soils in the watershed primarily consist of silt with varying proportions of sand, gravel, and clay. The dominant land use in the watershed is urban (76%), followed by forest (20%), agriculture (2%), barren (1%), and wetlands (1%).

Protection and Restoration Priorities

MBSS sampled 17 sites and stream waders sampled 28 sites in the Baltimore Harbor watershed. A large number of MBSS sampling sites (14 or 82%) in this watershed were degraded (received Poor scores) according to the fish or benthic macroinvertebrate IBIs. No streams were considered minimally degraded (received Good Scores). As a result, no catchments in the Baltimore Harbor watershed were given top priority for protection and restoration. The streams in the catchments of seven sites on three streams (Sawmill Creek, an unnamed tributary to Sawmill Creek, and Marley Creek) were given second tier priority for protection and restoration in this watershed based on Fair IBI scores (Figure 7). Focusing restoration and protection on catchments of these streams first may provide the most widespread ecological benefit to the watershed. Many sites showing degradation by MBSS and Stream Waders were located in catchments that were given second tier priority for protection and restoration. These degraded sites could be a basis for locating specific areas that require restoration within priority catchments.

Potential Point Sources of Pollution

A total of six NPDES permits have been issued to facilities in the Baltimore Harbor watershed. All of these are located in the Sawmill Creek watershed (recommended as second tier priority for protection and restoration; Figure 13).

Good Quality or Degraded Variables

The majority of FIBI and BIBI scores were in the Poor range (less than 3.0 on a scale of 1-5) in the watershed indicating that human influences to biota are widespread. The relatively large amount of urbanization, low dissolved oxygen, and poor physical habitat in most of the streams in this watershed were also indicative of degradation (Table 1). Despite extensive urbanization temperature logger data collected during 2001 indicated that water temperatures did not exceeded the water quality criteria maximum temperature for any streams in the watershed (Use Class I; 32.0 ^{o}C). This indicates that the biota the Baltimore Harbor watershed do not experience severe thermal stress in most streams.

Probable Stressors to Biota

The most prevalent stressors to fish based on species absence where they were expected to occur in the Baltimore Harbor watershed, included urbanization in stream catchments, low dissolved oxygen, acidity, and poor physical habitat quality (Table 8). All of these stressors are indicative of a highly urbanized area like the Baltimore Harbor watershed.

Summary

Most of the streams in the Baltimore Harbor watershed appear to be severely degraded due to extensive urbanization in the watershed. If restoration efforts are focused on this watershed they are likely to have the most benefit to the resources of the watershed if they are directed first in the least degraded catchments. Stream bank stabilization, and nutrient reduction initiatives should provide some protection to stream resources. However, limiting urban development in the least degraded catchments and providing sufficient vegetated riparian buffers along streams are likely to provide the greatest long-term benefit.

Oxon Creek

Landscape

The Oxon Creek watershed is located in the Coastal Plain physiographic province in Prince George's County Maryland and encompasses 6,891 acres. The geology and soils of the Oxen Creek watershed are similar to the Baltimore Harbor watershed. The primary geologic strata in the area consist of unconsolidated mud, clay, quartz, silt, sand, and gravel, along with weathered risidium from which iron and carbonate have been removed. Additional geologic strata include some organic rich deposits (including peat), and iron rich greensand. Soils in the watershed primarily consist of silt with varying proportions of sand, gravel, and clay. The dominant land use in the watershed is urban (72%), followed by forest (24%), agriculture (3%), and barren (<1%).

Protection and Restoration Priorities

MBSS sampled eight sites in the Oxon Creek watershed. Stream Waders did not sample any sites in the watershed. All eight sites had Poor scores for the fish and benthic macroinvertebrate IBIs indicating severe, widespread degradation. Therefore, no catchments were given top or second tier priority for restoration and protection (Figure 8). The greatest benefits to ecological resources are likely to be realized if restoration and protection funds were focused first in watersheds with better quality, rare, or unique conditions. Human health issues that may be resulting from urbanization effects on water quality may be a more important initial focus for this watershed compared to ecological restoration.

Potential Point Sources of Pollution

Only one Industrial NPDES permit has been issued to the Metro Bus Garage in the Oxon Creek watershed (Figure 14). This permit allows discharge near the border of Prince George's County and Washington D.C. at the northern border of the watershed.

Good Quality or Degraded Variables

Urban land use, impervious surface, and instream habitat at most sites in this watershed were indicative of severely degraded streams (Table 2). Physical habitat was extremely poor in two tributaries to Oxon Run (all scores were one or less on a scale of 0 to 20). Vegetated buffers were lacking at many sites and nitrates and sulfates were elevated at several sites. Despite extensive urbanization, temperature logger data collected during 2001 indicated that water temperatures did not exceeded the water quality criteria maximum temperature for any streams in the watershed (Use Class I; 32 ^{o}C). This indicates that the biota the Oxon Creek watershed may not experience severe thermal stress in most streams.

Probable Stressors to Biota

The most prevalent stressors to fish based on species absence where they were expected to occur in the Oxon Creek watershed were similar to those found in the Baltimore Harbor watershed. These stressors included urbanization in stream catchments and poor physical habitat quality (Table 8).

Summary

Widespread urbanization appears to have had a severe impact on the biological, physical, and chemical conditions throughout the Oxon Creek watershed. Restoring the ecological condition of this watershed would require mammoth efforts and a great deal of funds. Many human health issues such as leaking sewer lines and high bacteria levels in streams of this watershed are likely to require attention. Because of the effort that would be required to restore ecological integrity to streams in this watershed, ecological restoration should probably be focused in other watersheds first while human health issues are addressed in the Oxon Creek watershed.

<u>Patuxent River Middle</u>

Landscape
The Patuxent River Middle watershed is located in Anne Arundel, Calvert, and Prince Georges Counties, Maryland, and should not be confused with the Middle Patuxent River watershed in Howard County Maryland. The Patuxent River Middle watershed encompasses 66,478 acres and is entirely in the Coastal Plain physiographic province. The geologic strata in the area are dominated by unconsolidated mud and clay with mixtures of quartz, silt, sand, weathered residium, organic rich deposits, and iron rich greensand. These rock types also tend to provide relatively little acid-neutralizing capacity and are highly porous (McCartan et. al. 1998). Sand is the dominant soil type in the Patuxent River Middle watershed. Silt, clay, and gravel are also abundant. The dominant land use in the watershed is forest (47%), followed by agriculture (35%), urban (13%), and wetlands (3%).

Protection and Restoration Priorities
MBSS sampled 20 sites and Stream Waders sampled 24 sites in the Patuxent River Middle watershed. Fifteen (75%) MBSS sites had Poor scores for the fish or benthic macroinvertebrate IBI. Four sites (20%) on three streams (Lyons Creek, Mattaponi Creek, and District Branch) had Good scores for the fish or benthic macroinvertebrate IBI. The streams in the catchments draining to these four sites, should receive top priority for protection and restoration (Figure 9). Two sites, one on Mattaponi Creek and one on Lyons Creek, had both fish and benthic IBI scores in the Good range.

Potential Point Sources of Pollution
A large number (16) industrial and municipal NPDES permits have been issued in the Patuxent River Middle watershed. None of them, however, are located in catchments that are recommended as top priority for protection and restoration. (Figure 15).

Good Quality or Degraded Variables
Less than one quarter of the stream sites sampled in the Patuxent River Middle watershed were in the Good range for the benthic macroinvertebrate or fish IBIs (10% and 22% respectively). About half of the sites scored in the Poor range for these two indices (50% and 61% respectively). The most prevalent impacts to the Patuxent River Middle watershed appear to be moderately elevated nitrate levels, stream bank erosion, turbidity, and relatively low pH (<6.5) in some streams (Table 3). Many MBSS and Stream Waders sites with severe degradation were located in the catchments of streams identified as in need of protection and could be a basis for beginning to locate areas within priority protection watersheds that require restoration.

Probable Stressors to Biota
Acidity was the only stressor that corresponded to fish species absence where they were expected to occur in the Patuxent River Middle watershed. Acidity was identified at three sites as a probable stressor (Table 9). Acidity may be an important source of stress to other sites in this watershed

since degradation was relatively prevalent and since one time pH readings may have missed critical values at other sites.

Summary
About half of the streams in the Patuxent River Middle watershed appear to be degraded. Erosion, nutrients, and acidity appear to be the dominant stressors. Stream bank stabilization, riparian buffer planting projects, and nutrient reduction initiatives should provide some improvement to stream resources. However, additional sampling may be required to determine the possible influence of acidity and other stressors on the watershed.

<u>Piscataway Creek</u>

Landscape
The Piscataway Creek watershed is located in Prince George's County Maryland and encompasses 43,579 acres. It is located in the Coastal Plain physiographic province. The primary geologic strata in the area are similar to Baltimore Harbor and Oxon Creek and consist of unconsolidated mud, clay, quartz, silt, sand, and weathered residium. Greensand and iron ore are also present. Sand is the dominant soil type in the Piscataway Creek watershed. Silt, clay, and gravel are also abundant. The dominant land use in the watershed is forest (48%), followed by urban (34%), agriculture (16%), barren (1%), and wetlands (<1%).

Protection and Restoration Priorities
MBSS sampled 17 sites and Stream Waders sampled 18 sites in the Piscataway Creek watershed. Four MBSS sites (24%) on two streams (Piscataway Creek and a tributary to Whetstone Run) had Good scores for the fish or benthic macroinvertebrate IBIs. The streams in the catchments draining to these four sites should receive top priority for protection and restoration (Figure 10).

Potential Point Sources of Pollution
Only three NPDES permits have been issued in the Piscataway Creek watershed. Two (the Maryland State Military Facility and the Cheltenham Boys Village) are located in a portion of the watershed that is recommended as top priority for protection and restoration (Figure 16).

Good Quality or Degraded Variables
Thirteen MBSS sites (72%) scored in the Poor range for either the fish or benthic macroinvertebrate IBI indicating that degradation is relatively widespread in the Piscataway Creek watershed. Urbanization and concomitant factors including erosion, poor physical habitat, and relatively low dissolved oxygen levels are the most prevalent impacts to the Piscataway Creek watershed (Table 4). Many MBSS and Stream Waders sites with severe degradation were located in the catchments of streams identified as in need of protection and could be a basis for beginning to locate areas within priority protection watersheds that require restoration.

Possible Stressors to Biota
Acidity and poor physical habitat quality were identified as probable stressors to biota at three sites in the Piscataway Creek watershed (Table 10). Piscataway Creek is located next to the Patuxent River Middle watershed and has a similar soil with poor buffering capacity for acidity. Therefore, like the Patuxent River Middle watershed, acidity may be an important stressor to other degraded sites in the watershed. Poor physical habitat quality is likely due to the large amount of urbanization in the watershed.

Summary

Many of the streams in the Piscataway Creek watershed are degraded. Urbanization appears to be an important source of degradation while acidity may also be important. Although many regulations have been implemented to control acid deposition, acid precipitation remains a source of degradation to many areas. This is most likely due to the lack of buffering in the soils of the watershed and may be difficult to mitigate without imposing additional limits on the sources of acidifying emissions. The effects of urbanization to many streams in this watershed may be ameliorated to some degree by providing sufficient riparian buffers and protecting streams from urban run off.

<u>Western Branch</u>

Landscape

The Western Branch watershed is located in Prince George's County, Maryland, and encompasses 59,407 acres. It is located within the Coastal Plain physiographic province. The primary geologic strata in the area consist of iron rich green sand and bog iron ore but also consist of unconsolidated clay, silt, and mud. These rock types tend to provide relatively little acid-neutralizing capacity (McCartan et. al. 1998). Soils in the watershed primarily consist of silt with varying proportions of sand and clay. The dominant land use in the watershed is forest (39%), followed by urban (34%), agriculture (26%), barren (2%), and wetlands (<1%).

Protection and Restoration Priorities

MBSS sampled 38 sites and Stream Waders sampled 59 sites in the Western Branch watershed. Thirteen MBSS sites (34%) on seven streams (Lottsford Branch, Back Branch, Black Branch, Bald Hill Branch, Northeast Branch of Western Branch, Southwest Branch, and the Western Branch Mainstem) had Good scores for the fish IBI. Endangered species of fishes, including glassy darters (*Etheostoma vitreum*) and stripeback darters (*Percina notogramma*), were also collected from ten sites on four streams (Lottsford Branch, Bald Hill Branch, Collington Branch, and Western Branch Mainstem. The streams in the catchments draining to the sites with high IBI scores or endangered species should receive high priority for protection and restoration (Figure 11). The entire Western Branch watershed should be prioritized for restoration and protection based on the approach used in this report. This is due to the large number of sites with Good IBI scores and rare or endangered species along with the mainstem of Western branch having a Good IBI score and rare and endangered species.

Potential Point Sources of Pollution

Two facilities in the Western Branch watershed have been issued NPDES permits including the NASA Goddard Center and the Western Branch Treatment Facility. The NASA Goddard center is at the northern edge of the watershed and is located in a catchment that is recommended as top priority for protection and restoration. The Western Branch Facility is at the downstream end of the watershed and, as a result, is likely to influence the water quality of the Patuxent River more than Western Branch (Figure 17).

Good Quality or Degraded Variables

The Western Branch watershed is a particularly important watershed in which restoration and protection should be focused due to the presence of state endangered and rare species at a relatively large number of sites in the watershed. Although the fish IBI scored in the Good range for thirteen sites, no sites scored in the Good range for the benthic macroinvertebrate IBI and ten sites (26%)

scored low for both the fish and the benthic macroinvertebrate IBI. Erosion is abundant and instream habitat structure is lacking in many streams which may explain the low IBI scores.

Probable Stressors to Biota
The Western Branch watershed is located near the Washington D.C. metropolitan area. As a result it suffers from increasing urban development. Many of the species that were expected to occur at streams in the watershed were absent most likely due to the influence of urbanization (Table 11). Along with urbanization, low dissolved oxygen and poor physical habitat quality, which often result from urbanization, were also identified as probable stressors.

Summary
The Western Branch is a unique watershed in Maryland because it harbors two state listed endangered fish species. However, the majority of streams in the Western Branch watershed appear to be degraded by anthropogenic sources. Protection of streams where these fishes occur from additional anthropogenic influence is the only way to insure the perpetuation of these species in the Western Branch watershed. Restoration of degraded streams (e.g. stream bank stabilization or riparian buffer plantings) is also necessary to protect rare species and maintain minimally degraded conditions where they occur. Restoration projects are also likely to improve conditions in even the least degraded streams. However, limiting urban development in minimally degraded catchments and providing sufficient vegetated riparian buffers along streams are likely to provide the greatest long-term benefit.

<u>Upper Pocomoke River</u>

Landscape
The Upper Pocomoke River watershed is located in Wicomico and Worchester Counties, Maryland, and encompasses 95,539 acres within the Coastal Plain physiographic province. The primary geologic strata in the area consist unconsolidated quartz, silt sand and gravel along with weathered risidium. These rock types tend to provide little acid-neutralizing capacity and are very porous (McCartan et. al. 1998). Soils in the watershed consist primarily of silt with varying proportions of sand and clay. The dominant land use in the watershed is forest (53%), followed by agriculture (45%), and urban (2%).

Protection and Restoration Priorities
MBSS sampled 55 sites and Stream Waders sampled 31 sites in the Upper Pocomoke River watershed. Seven (13%) MBSS sites on four streams (Adkins Race, South Fork Green Run, the South Fork of Green Run, and the Pocomoke River) had Good scores for the fish IBI (Figure 12). Four sites on three streams (Adkins Race, South Fork of Green Run, and the Pocomoke River) also contained state rare, or endangered species of fishes. The streams in the catchments draining to the sites with high IBI scores and/or rare species should receive top priority for protection and restoration. One site on Adkins Race received a good score for both the benthic macroinvertebrate and fish IBI. This was the only site with a Good score for the benthic macroinvertebrate IBI. The state endangered glassy darter was also collected at the site. All of these factors justify considering this site with the highest priority for protection and restoration in the Upper Pocomoke River watershed.

Potential Point Sources of Pollution
A total of two municipal NPDES permits have been issued within the Upper Pocomoke River watershed. Both of these permits have been issued to facilities that are located within catchments where endangered fishes reside (Figure 18).

Good Quality or Degraded Variables
The majority of MBSS sites scored in the Poor range for the Fish and benthic macroinvertebrate IBI in the Upper Pocomoke watershed indicating that human influences to biota are widespread. However, the presence of state endangered fish species at sites with Good fish IBI scores indicates that good quality conditions exist in the watershed. Poor physical habitat and high nitrate values were measured at a large majority of sites. This is most likely due to the widespread channelization of streams in this area.

Probable Stressors to Biota
Possible stressors to fishes were identified at relatively few sites considering the amount of degradation observed in the Upper Pocomoke River watershed. The probable stressors identified included acidity, poor physical habitat quality, riffle embeddedness, and possible thermal stress (Table 12). Even though degradation in many streams is indicated by Poor index of biotic integrity scores within this watershed, the cause of stress to biota that may result from widespread channelization of streams may be difficult to measure and diagnose.

Summary
Like the Western Branch, the Upper Pocomoke River watershed has state listed endangered species of fish making it a unique watershed in Maryland. Also like the Western Branch watershed, the majority of streams appear to be degraded by anthropogenic sources. Many streams in the Upper Pocomoke River watershed have been channelized, which may explain some of the degradation observed in the watershed. Restoring sinuosity to channelized streams in the Upper Pocomoke River watershed is likely to be extremely expensive and time consuming. However, maintaining vegetated buffers and limiting the amount of nutrient run-off entering streams is likely to improve conditions in even the least degraded streams.

Conclusions

This report is meant to convey information that could be used to provide the greatest possible benefit to stream ecological resources in the Upper Pocomoke River, Baltimore Harbor, Patuxent River Middle, Western Branch, Piscataway Creek, and Oxon Creek watersheds, based on the best monitoring data presently available. This report pertains exclusively to ecological resources and should be considered as part of a comprehensive watershed restoration and protection plan that also considers benefits to social and economic resources.

Specific areas in need of protection or restoration within the Upper Pocomoke River, Baltimore Harbor, Patuxent River Middle, Western Branch, Piscataway Creek, and Oxon Creek watersheds are identified in this report based on surveys of the watersheds by the Maryland Biological Stream Survey (MBSS). However, more comprehensive surveys of stream conditions with higher sample site densities and directed stream walks using methods like DNR's Stream Corridor Assessment survey (Yetman 2000), in the upstream catchments of minimally-degraded streams would provide additional information necessary to plan detailed restoration work that would ensure even greater benefits to streams in these watersheds. Volunteer sampling results from DNR's Stream Waders program are also presented in this assessment to help identify specific sites within areas prioritized for protection that are in need of restoration. With the abundance of biological, physical habitat, and chemical data available from the MBSS and Stream Waders program in these watersheds, supplemental surveys of stream bank erosion, width of vegetated riparian buffers, and general instream habitat quality could be used to identify areas where buffer planting projects, stream bank stabilization, storm water controls, or other restoration improvements could be implemented. In most cases, we recommend that a long-term, lower cost approach to stream habitat improvements such as riparian buffer planting projects be evaluated first before expensive channel modifications are considered. Ecological monitoring that includes the collection of biological, physical habitat, and chemical conditions throughout these priority watersheds should continue on a regular basis to document improvements in ecological conditions over time as restoration and protection strategies are implemented.

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Table 1. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Baltimore Harbor watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Baltimore Harbor									
Parameter	**103-01**	**104-01**	**106-01**	**108-01**	**110-01**	**113-01**	**202-01**	**207-01**	**214-01**
Fish IBI Score	1.00				2.00	1.75	3.75	3.25	3.75
Macroinvertebrate IBI Score	1.00	1.29	1.00	1.57	1.86	3.57	2.43	2.43	3.00
NO3	0.51	0.10	1.63	1.76	0.41	0.98	1.25	1.25	1.42
D.O. (mg/L)	0.3	0.9	8.6	6.3	7.4	8.3	7.0	4.0	4.5
pH (units)	7.61	6.02	6.92	7.85	6.96	7.00	6.80	6.75	6.70
Sulfate	20.87	21.34	33.75	36.80	33.12	25.09	23.47	16.45	14.99
Temperature (*= maximum summer temperature from temperature loggers)	16.8	*25.64	*29.74	*31.49	13.9	*28.40	*25.36	*23.63	*24.89
Turbidity	3.1	6.9	18.1	4.9	8.8	12.6	10.8	12.4	15.1
Instream Habitat Score	0	4	1	16	6	7	14	11	14
Epifaunal Substrate Score	0	2	1	13	4	11	13	10	6
Velocity/Depth Diversity	1	2	6	13	11	12	13	13	6
Pool Quality Score	2	6	1	14	11	11	14	16	17
Eroded Bank Area (m^2)	10	20	0	20	90	100	20	20	30
Erosion Severity Score	0.5	2.0	0.0	1.0	2.5	3.0	1.0	1.0	2.0
Bank Stability									
Embeddedness	100	100	0	55	70	75	55	50	100
Buffer Width	0	50	50	33	50	50	5	50	50
Agricultural Land Use (%)	12.45	10.26	4.61	13.79	5.16	27.15	30.38	12.59	7.33
Urban Land Use (%)	58.69	73.43	85.91	83.41	81.79	41.54	31.50	64.78	74.13
Impervious Land Cover (%)	20.36	24.07	28.59	41.22	31.64	15.06	11.53	23.44	27.11

Table1. Continued								
Baltimore Harbor								
Parameter	**114-95**	**203-95**	**209-95**	**306-95**	**101-96**	**115-96**	**124-96**	**225-96**
Fish IBI Score	2.00	2.50	3.00	3.00	1.00			3.50
Macroinvertebrate IBI Score	1.57	2.43	3.00	2.43	1.00	3.29	1.57	2.71
NO3	0.93	3.11	1.85	1.40	1.89	2.38	0.26	1.55
D.O. (mg/L)	5.00	2.00	4.00	6.00	14.60	11.80	4.90	4.90
pH (units)	6.90	6.99	6.67	6.77	6.99	6.66	5.75	6.56
Sulfate	19.16	26.89	24.29	21.85	22.61	14.77	20.60	25.47
Temperature	23.10	19.90	18.70	20.20	15.80	14.10	15.20	15.40
Turbidity								
Instream Habitat Score	6	12	7	12	0	12	12	16
Epifaunal Substrate Score	4	7	4	10	0	7	1	15
Velocity/Depth Diversity	6	13	10	16	6	7	3	13
Pool Quality Score	11	13	12	17	1	12	9	13
Eroded Bank Area (m^2)								
Erosion Severity Score								
Bank Stability	7	5	12	10	16	5	9	16
Embeddedness	80	50	50	50	100	95	100	85
Buffer Width	15	0	50	0	0	3	0	24
Agricultural Land Use (%)	9.78	10.60	27.80	14.35	2.64	4.90	16.67	25.36
Urban Land Use (%)	67.00	75.65	9.91	45.79	89.90	80.41	11.11	11.71
Impervious Land Cover (%)	30.76	22.33	3.09	16.93	30.17	22.14	2.78	3.96

Table 2. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Oxon Creek watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Oxon creek								
Parameter	**101-01**	**205-01**	**063-2-94**	**063-6-94**	**119-1-94**	**119-2-94**	**172-1-94**	**172-2-94**
Fish IBI Score	1.00	1.00	1.00	1.50				
Macroinvertebrate IBI Score	1.57	1.00	1.60	1.00	1.30	1.00	2.10	1.00
NO3	0.85	0.66		2.084	1.413		1.682	
D.O. (mg/L)	8.3	8.0	7.6	8.2	6.4	6.7		
pH (units)	7.52	7.39		6.99	7.41	6.85	7.39	
Sulfate	37.15	47.34		46.50	50.68		55.67	
Temperature (*= maximum summer temperature from temperature loggers)	*30.3	22.20	19.4	19.9	21	23.1		
Turbidity	22.80	9.30						
Instream Habitat Score	17	1	1	13	11	11		
Epifaunal Substrate Score	16	1	0	15	12	11		
Velocity/Depth Diversity	10	1	1	10	8	10		
Pool Quality Score	10	0	0	7	2	6		
Eroded Bank Area (m^2)	70	0						
Erosion Severity Score	2.0	0.0						
Bank Stability			19	11	6	14		
Embeddedness	50	100	99	65	35	40		
Buffer Width	10	1	0	0	17	6	20	13
Agricultural Land Use (%)	12.19	8.27	3.68	7.83	4.81	1.71	5.54	5.46
Urban Land Use (%)	65.08	62.29	70.45	64.85	65.18	78.7	66.12	66.5
Impervious Land Cover (%)	22.54	20.35	25.78	22.39	24.52	29.89	23.06	23.21

Table 3. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Patuxent River Middle watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Patuxent River Middle										
Parameter	**101-01**	**106-01**	**107-01**	**109-01**	**112-01**	**114-01**	**115-01**	**119-01**	**120-01**	**121-01**
Fish IBI Score	2.00	4.00	1.00	4.75	1.50	2.75	1.75		2.50	2.50
Macroinvertebrate IBI Score	3.29	4.14	1.86	2.43	1.29	3.00	3.29	2.43	2.14	2.71
NO3	1.73	0.38	0.88	1.15	1.41	0.73	1.85	1.93	2.04	0.00
D.O. (mg/L)	6.5	8.2	9.4	9.3	7.7	8.2	6.9	7.5	8.3	7.4
pH (units)	6.72	6.26	6.15	6.92	6.46	6.71	6.65	6.38	6.79	5.11
Sulfate	23.85	19.08	31.14	30.57	29.03	25.72	24.55	40.13	27.90	14.90
Temperature (*= maximum summer temperature from temperature loggers)	*24.53	*25.44	*27.53	21.20	19.00	*24.52	*24.57	*24.06	*28.79	*23.34
Turbidity	27.70	12.30	7.00	15.00	40.50	8.70	26.70	13.80	14.40	1.00
Instream Habitat Score	9	16	10	10	7	8	9	9	12	12
Epifaunal Substrate Score	7	16	10	10	6	14	10	8	8	16
Velocity/Depth Diversity	11	13	11	11	11	8	8	11	5	6
Pool Quality Score	11	13	11	11	11	8	9	11	8	7
Eroded Bank Area (m^2)	70	60	60	200	60	40	90	30	20	0
Erosion Severity Score	2.0	2.0	2.5	3.0	2.5	2.0	3.0	1.5	1.0	0.0
Bank Stability										
Embeddedness	45	35	55	45	60	45	40	90	100	70
Buffer Width	50	5	40	50	45	20	50	15	50	50
Agricultural Land Use (%)	65.54	24.05	35.65	52.11	72.10	52.87	67.39	56.11	69.97	39.46
Urban Land Use (%)	2.57	11.80	12.45	0.72	6.03	2.26	4.53	20.36	2.60	0.00
Impervious Land Cover (%)	1.03	3.45	3.21	0.18	1.60	0.70	1.88	6.56	0.95	0.00

Table 3. Continued

Patuxent River Middle										
Parameter	**122-01**	**211-01**	**213-01**	**101-97**	**103-97**	**124-97**	**138-97**	**226-97**	**231-97**	**302-97**
Fish IBI Score	2.00	3.00	3.25		1.75	2.75	2.75	4.75	3.75	4.75
Macroinvertebrate IBI Score	3.00	3.57	2.71	1.30	2.40	2.70	3.00	4.10	3.00	3.90
NO3	0.51	0.71	1.05	1.98	0.712	0.78	0.93	1.12	0.98	1.21
D.O. (mg/L)	9.1	8.2	6.9	8.4	9.6	7.6	9.3	6.8	6.9	7.9
pH (units)	6.60	6.64	6.84	6.69	6.37	7.00	6.58	6.83	6.81	6.64
Sulfate	26.72	32.20	26.14	19.68	33.97	31.54	26.86	26.69	33.65	26.06
Temperature (*= maximum summer temperature from temperature loggers)	*24.56	17.80	20.50	15.50	13.10	20.40	15.40	23.10	24.40	22.30
Turbidity	18.40	7.30	14.00							
Instream Habitat Score	14	17	8	8	7	7	9	11	12	5
Epifaunal Substrate Score	12	16	7	11	11	4	12	5	5	5
Velocity/Depth Diversity	11	17	15	11	11	13	9	9	9	11
Pool Quality Score	11	15	15	11	11	13	11	13	16	8
Eroded Bank Area (m^2)	100	80	250							
Erosion Severity Score	2.50	2.00	3.00							
Bank Stability				8	5	4	7	6	6	7
Embeddedness	40	30	35	35	25	95	30	100	100	100
Buffer Width	50	50	50	21	50	0	50	50	50	0
Agricultural Land Use (%)	26.79	31.23	62.82	45.97	22.22	22.39	52.20	59.68	35.09	58.07
Urban Land Use (%)	0.75	6.45	4.46	18.27	5.39	15.91	2.56	7.23	11.01	6.58
Impervious Land Cover (%)	0.19	1.89	1.26	4.94	1.50	4.32	0.77	2.16	3.27	1.90

Table 4. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Piscataway Creek watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Piscataway Creek										
Parameter	**103-01**	**104-01**	**105-01**	**106-01**	**109-01**	**112-01**	**113-01**	**115-01**	**201-01**	**207-01**
Fish IBI Score	3.25	2.00	3.00	3.00	3.50	3.50	3.50		2.50	4.25
Macroinvertebrate IBI Score	2.14	2.71	1.57	2.71	2.71	2.43	2.43	2.14	1.57	
NO3	0.91	0.47	0.44	0.41	1.12	0.26	0.95	0.28	0.94	0.47
D.O. (mg/L)	6.7	9.5	3.6	6.0	6.5	7.8	6.1	7.7	7.4	6.5
pH (units)	7.21	7.95	6.39	6.61	7.19	6.51	6.91	5.99	6.83	7.05
Sulfate	22.11	28.99	19.28	18.06	22.37	16.62	19.80	26.49	20.83	19.33
Temperature (*= maximum summer temperature from temperature loggers)	21.10	*26.13	*26.76	*25.63	22.90	*27.49	*28.47	*24.41	*27.48	*27.14
Turbidity	8.10	1.20	4.90	16.60	3.20	12.60	3.80	4.80	12.00	10.40
Instream Habitat Score	13	16	9	12	10	13	14	3	7	12
Epifaunal Substrate Score	10	18	3	15	11	17	12	2	11	11
Velocity/Depth Diversity	12	9	7	8	11	12	15	3	11	12
Pool Quality Score	12	10	8	9	12	11	14	4	11	16
Eroded Bank Area (m^2)	50	70	20	90	100	70	40	40	80	40
Erosion Severity Score	2.0	2.5	1.5	3.0	2.0	2.0	1.5	3.0	2.5	2.0
Bank Stability										
Embeddedness	20	17	15	40	35	25	16	75	40	30
Buffer Width	45	40	50	50	48	50	40	40	50	40
Agricultural Land Use (%)	18.08	18.26	3.36	16.20	16.47	9.73	35.46	8.53	16.66	31.45
Urban Land Use (%)	65.36	14.72	33.51	17.31	70.10	11.51	40.82	20.85	47.10	22.56
Impervious Land Cover (%)	24.10	3.86	8.49	4.49	26.02	3.09	13.59	7.74	12.46	8.79

Table 4. Continued

Piscataway Creek							
Parameter	**125-97**	**128-97**	**201-97**	**321-97**	**327-97**	**069-1-94**	**069-2-94**
Fish IBI Score	3.50		4.75	3.25	4.25		2.50
Macroinvertebrate IBI Score	2.71	2.14	4.14	2.43	3.86	3.6	4.4
NO3	0.60	0.95	1.01	0.72	0.71	1.153	
D.O. (mg/L)	3.0	3.1	3.8	2.8	2.7	9.1	9.4
pH (units)	6.75	6.85	6.92	7.02	6.97	6.51	6.1
Sulfate	19.85	19.91	21.87	22.19	22.86	13.704	
Temperature	26.50		21.00	21.20	25.60	18.2	18.4
Turbidity							
Instream Habitat Score	7		17	12	12	15	16
Epifaunal Substrate Score	1		6	10	7	14	16
Velocity/Depth Diversity	5		15	15	13	13	11
Pool Quality Score	7		16	20	19	9	11
Eroded Bank Area (m^2)							
Erosion Severity Score							
Bank Stability	16		16	12	13	8	4
Embeddedness	100		35	45	35	25	45
Buffer Width	50		50	50	50	0	50
Agricultural Land Use (%)	28.11	19.17	23.30	24.71	22.92	19.72	21.30
Urban Land Use (%)	9.75	54.44	19.03	17.21	23.34	6.12	6.41
Impervious Land Cover (%)	2.89	18.98	6.67	5.43	7.74	1.53	1.60

Table 5. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Western Branch watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Western Branch										
Parameter	**104-01**	**105-01**	**106-01**	**107-01**	**110-01**	**111-01**	**113-01**	**116-01**	**201-01**	**212-01**
Fish IBI Score		4.50	2.25	3.25	4.75	4.75		3.50	4.50	2.75
Macroinvertebrate IBI Score	2.71	2.43	1.86	2.43	2.71	2.71	2.71	1.86	3.00	1.86
NO3	0.28	0.87	0.24	0.35	0.45	0.88	0.38	1.00	0.32	0.41
D.O. (mg/L)		7.2	2.3	1.9	6.9	7.4	8.2	7.7	3.9	6.7
pH (units)	7.13	7.16	7.12	6.46	7.20	7.18	7.22	6.28	7.05	7.37
Sulfate	17.58	31.42	24.76	17.62	26.52	31.48	54.73	25.89	17.69	39.30
Temperature (*= maximum summer temperature from temperature loggers)	*29.68	*24.54	*28.98	21.30	*26.20	*24.54	*28.22	*24.13	23.10	*27.61
Turbidity	0.00	5.90	5.90	95.40	18.50	5.00	9.40	9.50	13.20	4.40
Instream Habitat Score		13	8	12	12	15	12	13	11	13
Epifaunal Substrate Score		14	14	11	4	15	12	10	9	10
Velocity/Depth Diversity		12	7	10	12	12	11	12	7	13
Pool Quality Score		13	7	15	14	14	15	12	9	15
Eroded Bank Area (m^2)		20	20	0	150	30	40	20	210	80
Erosion Severity Score		1.0	2.0	0.0	2.5	2.0	2.0	1.0	3.0	2.0
Bank Stability										
Embeddedness		20	35	100	40	17	35	100	35	25
Buffer Width	35	50	10	45	50	50	50	50	50	50
Agricultural Land Use (%)	17.12	45.48	36.22	69.73	65.12	45.52	69.47	27.51	24.16	27.54
Urban Land Use (%)	33.49	8.13	7.87	3.71	1.56	8.16	0.11	28.11	31.82	41.37

Impervious Land Cover (%)	11.13	2.26	2.61	1.34	0.76	2.27	0.08	7.52	9.99	15.26

Table 5. Continued										
Western Branch										
Parameter	**113-97**	**115-97**	**122-97**	**135-97**	**212-97**	**213-97**	**215-97**	**223-97**	**305-97**	**306-97**
Fish IBI Score	2.00			1.00	3.25	4.50	4.75	4.75	4.00	4.50
Macroinvertebrate IBI Score	2.14	1.29	2.14	2.14	2.43	3.57	2.71	2.14	1.29	3.57
NO3	0.67	0.43	0.80	0.61	0.55	0.74	0.79	0.82	0.71	0.57
D.O. (mg/L)	6.1	6.8	7.5	5.1	4.7	6.6	2.5	2.3	5.7	4.0
pH (units)										
Sulfate	19.83	19.01	326.95	26.71	24.83	17.55	24.65	23.49	26.09	21.61
Temperature	21.20	17.20	13.30	17.10	16.10	18.90	23.50	25.60	22.00	22.90
Turbidity										
Instream Habitat Score	2	5	9	7	11	7	7	6	10	12
Epifaunal Substrate Score	2	5	11	11	11	6	4	5	6	10
Velocity/Depth Diversity	7	7	10	9	13	11	8	9	11	13
Pool Quality Score	6	6	11	8	14	16	16	11	18	17
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	1	15	9	4	7	2	5	4	7	4
Embeddedness	100	95	25	35	35	100	90	50	90	98
Buffer Width	50	14	0	34	0	50	12	0	50	50
Agricultural Land Use (%)	63.69	57.39	17.96	52.71	50.26	22.49	53.06	55.71	25.73	34.26
Urban Land Use (%)	1.71	5.99	17.47	26.02	22.61	37.44	9.20	5.73	42.17	26.69
Impervious Land Cover (%)	0.94	2.36	4.49	12.64	10.74	12.03	2.61	1.71	15.59	8.45

Table 5. Continued

Western Branch

Parameter	**324-97**	**003-2-94**	**003-3-94**	**087-2-94**	**087-3-94**	**141-1-94**	**141-2-94**	**194-1-94**	**194-2-94**
Fish IBI Score	4.75	2.75	3.25	2.00		4.25	4.00	3.25	3.75
Macroinvertebrate IBI Score	2.71	1.30	1.00	2.10	1.90	1.60	2.70	2.10	1.90
NO3	0.67		0.66	0.98		0.85		0.73	
D.O. (mg/L)	3.8	6.3	8.1	1.9		5.6	8.6	8.0	6.8
pH (units)		6.28	6.79	6.18		6.65	6.45	6.75	6.97
Sulfate	21.49		18.90	19.30		21.35		22.22	
Temperature	22.20	22.5	24.60	18.00		23	20.90	22.20	17.50
Turbidity									
Instream Habitat Score	14	17	14	2		8	5	7	14
Epifaunal Substrate Score	11	14	11	2		9	2	11	6
Velocity/Depth Diversity	13	10	16	3		12	8	14	12
Pool Quality Score	18	15	16	6		13	5	13	15
Eroded Bank Area (m^2)									
Erosion Severity Score									
Bank Stability	4	2	11	2		11	7	4	3
Embeddedness	100	98	40	95		60	100	80	85
Buffer Width	50	0	50	50		0	0	50	50
Agricultural Land Use (%)	34.07	9.01	9.01	13.71	20.14	9.02	24.66	17.29	17.79
Urban Land Use (%)	26.65	34.28	34.27	4.74	8.96	34.30	9.34	18.50	19.98
Impervious Land Cover (%)	8.44	11.02	1.87	3.53	2.37	2.64	5.82	6.26	

Table 5. Continued										
Western Branch										
Parameter	**205-2-94**	**205-4-94**	**206-1-94**	**206-2-94**	**219-1-94**	**219-5-94**	**259-1-94**	**259-2-94**	**271-9-94**	
Fish IBI Score	1.00	4.00	2.00	2.25		3.75	3.75	3.75	1.00	
Macroinvertebrate IBI Score	2.40	1.90	1.90	2.70	1.00	1.60	1.60	2.10	1.60	
NO3		1.19	0.81		0.706	0.693		0.76	4.33	
D.O. (mg/L)	9.2	8.5	6.1	8.6	5.6	4.9	8.8	8.3	2.4	
pH (units)	6.34	6.70	6.41	6.42	6.76	6.76	6.94	6.80	6.07	
Sulfate		17.00	24.19		20.22	19.85		21.79	38.65	
Temperature	13.50	19.50	19.80	18.90	23.70	25.10	18.00	19.50	20.00	
Turbidity										
Instream Habitat Score	3	4	9	1	4	5	7	9	0	
Epifaunal Substrate Score	3	5	2	1	2	3	2	5	0	
Velocity/Depth Diversity	7	12	9	6	8	12	16	8	0	
Pool Quality Score	4	11	1	0	12	12	14	16	0	
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	4	6	19	2	2	3	6	6	1	
Embeddedness	85	100	100	100	100	100	50	75	99	
Buffer Width	50	0	50	0	50	50	50	50	14	
Agricultural Land Use (%)	14.24	14.26	26.83	25.31	13.47	13.45	14.56	14.51	50.10	
Urban Land Use (%)	28.67	34.08	5.03	4.78	26.83	26.68	13.18	13.14	2.13	
Impervious Land Cover (%)	7.27	9.50	1.53	1.51	8.53	8.49	4.20	4.19	0.80	

Table 6. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Upper Pocomoke River watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

Upper Pocomoke River										
Parameter	**101-01**	**103-01**	**105-01**	**106-01**	**107-01**	**113-01**	**114-01**	**115-01**	**117-01**	**118-01**
Fish IBI Score		3.50	3.25	1.50	4.50	3.00	4.00	2.50	1.00	3.50
Macroinvertebrate IBI Score	1.29	2.71	1.57	2.14	3.29	2.43	2.43	1.57	2.71	2.43
NO3	0.10	3.48	1.46	1.26	4.93	0.73	5.10	5.32	0.10	2.80
D.O. (mg/L)		8.2	1.8	4.0	8.9	1.8	9.2	4.6	1.3	5.5
pH (units)	4.37	7.05	6.64	6.40	6.50	6.50	6.54	7.36	5.00	6.34
Sulfate	7.35	13.64	15.06	44.70	20.30	12.00	20.38	28.45	16.60	13.20
Temperature (*= maximum summer temperature from temperature loggers)		*28.93	*25.86	21.90	*31.33	*25.86	27.60	31.50	*26.7	20.50
Turbidity		7.40	11.00	22.90	9.50	11.00	6.40	24.80	76.00	7.50
Instream Habitat Score		14	10	7	18	8	17	9	3	16
Epifaunal Substrate Score		5	10	4	15	11	12	5	4	11
Velocity/Depth Diversity		9	5	5	15	5	5	4	4	9
Pool Quality Score		14	10	6	17	10	10	9	6	14
Eroded Bank Area (m^2)		0	0	60	0	0	0	20	0	0
Erosion Severity Score		0.0	0.0	1.5	0.0	0.0	0.0	3.0	0.0	0.0
Bank Stability										
Embeddedness		100	100	100	100	100	100	100	100	100
Buffer Width	50	0	50	0	0	50	50	0	13	0
Agricultural Land Use (%)	0.97	65.74	37.42	87.01	52.41	37.73	53.35	70.09	4.48	59.74
Urban Land Use (%)	0.00	0.01	3.53	0.32	5.12	3.40	4.23	7.56	0.00	0.00
Impervious Land Cover (%)	0.00	0.00	1.63	0.18	2.14	1.57	1.90	2.74	0.00	0.00

Table 6. Continued

Upper Pocomoke River										
Parameter	**204-01**	**216-01**	**410-01**	**103-97**	**104-97**	**106-97**	**107-97**	**114-97**	**205-97**	**206-97**
Fish IBI Score	2.50	2.00	3.00	3.75		2.25	2.25	2.75		3.75
Macroinvertebrate IBI Score	1.86	2.14	3.57	1.86	1.57	2.14	1.00	1.57	1.86	2.43
NO3	0.67	0.78	2.63	4.29	3.05	4.82	0.52	5.41	4.01	4.73
D.O. (mg/L)	4.7	4.7	5.2	10.7	10.0	25.6	10.9	10.6	8.4	8.1
pH (units)	6.60	6.61	6.26	6.31	5.98	5.98	4.57	6.09	6.39	6.38
Sulfate	20.01	20.95	13.68	14.79	14.24	17.29	7.25	16.10	19.77	15.02
Temperature (*= maximum summer temperature from temperature loggers)	*25.59	*25.59	20.40	26.50		20.40	19.70	19.30		23.90
Turbidity	8.40	8.40	14.50							
Instream Habitat Score	17	8	13	10		1	4	6		16
Epifaunal Substrate Score	11	5	13	5		1	3	5		13
Velocity/Depth Diversity	6	8	10	12		2	2	5		6
Pool Quality Score	17	6	15	10		2	2	6		15
Eroded Bank Area (m^2)	0	0	160							
Erosion Severity Score	0	0	1							
Bank Stability				13		1	11	11		16
Embeddedness	100	100	100	100		100	100	100		100
Buffer Width	6	50	50	30		0	0	23		3
Agricultural Land Use (%)	48.02	51.87	51.31	67.89	61.99	51.50	49.19	51.43	67.05	67.32
Urban Land Use (%)	0.60	0.67	0.20	0.00	0.00	0.03	5.23	0.09	0.03	0.04
Impervious Land Cover (%)	0.40	0.45	0.09	0	0	0.02	2.06	0.07	0.02	0.02

Table 6. Continued

Upper Pocomoke River										
Parameter	**207-97**	**208-97**	**210-97**	**217-97**	**219-97**	**303-97**	**305-97**	**306-97**	**308-97**	**309-97**
Fish IBI Score	3.75	4.00	3.00	3.25	3.75	3.00	3.00	3.5	2.75	4.00
Macroinvertebrate IBI Score	2.71	3.00	2.71	2.71	1.57		3.57	3.00	3.57	3.00
NO3	4.05	4.52	4.53	5.21	2.56	2.87	3.77	3.36	3.32	2.28
D.O. (mg/L)	9.1	11.7	11.1	10.4	9.7	11.7	11.0	12.9	12.3	13.4
pH (units)	6.30	6.49	6.28	6.51	6.52	6.20	6.00	6.00	5.93	6.32
Sulfate	14.74	14.57	15.26	14.92	12.95	14.32	13.26	13.04	12.92	10.79
Temperature	20.80	30.90	20.20	28.90	21.50	22.70	22.00	25.30	24.80	19.00
Turbidity										
Instream Habitat Score	10	14	5	12	10	11	7	14	12	15
Epifaunal Substrate Score	9	10	3	10	6	10	6	14	11	14
Velocity/Depth Diversity	10	10	6	8	11	8	8	6	5	10
Pool Quality Score	13	10	11	10	15	16	7	11	6	14
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	8	15		17	11	10	11	10	10	15
Embeddedness	100	100	100	100	100	100	100	100	100	100
Buffer Width	10	10	0	3	0	50	50	5	3	50
Agricultural Land Use (%)	52.14	71.86	55.60	71.40	54.59	50.29	51.35	51.03	50.92	42.98
Urban Land Use (%)	4.46	0.01	4.16	0.04	3.99	1.41	0.21	0.20	0.20	1.76
Impervious Land Cover (%)	1.80	0.00	1.69	0.03	1.62	0.60	0.09	0.08	0.08	0.88

Table 6. Continued

Upper Pocomoke River										
Parameter	**311-97**	**312-97**	**314-97**	**315-97**	**318-97**	**319-97**	**320-97**	**WI-S-005-1**	**WI-S-005-4**	**WI-S-054-1**
Fish IBI Score	4.50	3.5	3.25	3.00	3.00	4.25	4.00			
Macroinvertebrate IBI Score	4.14	3.00	3.86	3.86	3.00	3.57	3.57	1.60	1.30	2.10
NO3	2.22	2.65	2.77	2.92	2.09	1.48	2.09		5.89	4.28
D.O. (mg/L)	14.3	11.6	11.8	10.7	13.5	15.8	13.3	5.2		5.6
pH (units)	6.34	6.12	6.15	6.23	6.24	6.55	6.29	6.67	5.69	5.91
Sulfate	10.89	11.84	12.45	13.00	11.32	9.56	11.56		17.35	15.08
Temperature	15.90	25.10	24.90	23.90	21.40	18.80	26.50	21.9		22.1
Turbidity										
Instream Habitat Score	17	9	10	8	14	19	12	11		15
Epifaunal Substrate Score	15	11	10	8	12	18	11	5		14
Velocity/Depth Diversity	10	8	5	7	10	10	5	1		9
Pool Quality Score	15	11	8	12	14	16	9	1		10
Eroded Bank Area (m^2)										
Erosion Severity Score						15				
Bank Stability	19	15	7	5	5		11	14.0		7.0
Embeddedness	100	100	100	100	100	100	100	99		99
Buffer Width	50	50	30	50	50	50	50	2		11
Agricultural Land Use (%)	43.35	51.09	50.65	51.96	51.27	43.01	51.00	7.90	9.70	11.00
Urban Land Use (%)	1.74	0.21	0.28	1.46	0.21	1.75	0.20	0.02	0.02	4.91
Impervious Land Cover (%)	0.87	0.09	0.12	0.61	0.09	0.87	0.09	0.02	0.01	1.96

Table 6. Continued

Upper Pocomoke River										
Parameter	**WI-S-054-2**	**WI-S-057-1**	**WI-S-057-3**	**WI-S-059-1**	**WI-S-059-2**	**WI-S-060-2**	**WI-S-060-3**	**WO-S-008-1**	**WO-S-008-3**	**WO-S-040-2**
Fish IBI Score								3.50	3.50	
Macroinvertebrate IBI Score	2.40	2.70	1.30	1.60	1.30	1.00	1.90	1.00	2.10	1.30
NO3		2.52		4.80		1.05		1.83		4.29
D.O. (mg/L)	6.1		4.2					5.6	5.8	
pH (units)	6.40	5.92	6.64	5.01		5.54		5.76	6.58	4.40
Sulfate		11.45		16.77		22.37		10.96		6.66
Temperature	22.1		22.6					21.6	21.6	
Turbidity										
Instream Habitat Score	11		18					8	4	
Epifaunal Substrate Score	6		16					4	3	
Velocity/Depth Diversity	7		10					5	4	
Pool Quality Score	6		11					7	6	
Eroded Bank Area (m^2)										
Erosion Severity Score										
Bank Stability	7.0		12.0					11.0	12.0	
Embeddedness	99		99					99	99	
Buffer Width	10		50					50	50	
Agricultural Land Use (%)	10.94	8.24	8.27	7.82	4.22	8.37	9.50	8.66	8.65	1.31
Urban Land Use (%)	4.93	1.74	1.76	0.02	0.04	0.00	0.00	0.28	0.28	0.00
Impervious Land Cover (%)	1.97	0.87	0.88	0.02	0.03	0.00	0.00	0.13	0.13	0.00

Table 6. Continued

Upper Pocomoke River					
Parameter	**WO-S-040-3**	**WO-S-058-1**	**WO-S-058-2**	**WO-S-060-1**	**WO-S-060-2**
Fish IBI Score		1.00	2.40	1.30	1.00
Macroinvertebrate IBI Score	1.60	1.00	2.43	1.30	1.00
NO3			0.70	3.71	
D.O. (mg/L)					
pH (units)			6.22	6.47	
Sulfate			22.07	14.14	
Temperature					
Turbidity					
Instream Habitat Score					
Epifaunal Substrate Score					
Velocity/Depth Diversity					
Pool Quality Score					
Eroded Bank Area (m^2)					
Erosion Severity Score					
Bank Stability					
Embeddedness					
Buffer Width					
Agricultural Land Use (%)	1.23	16.39	16.18	11.43	14.05
Urban Land Use (%)	0.00	0.70	0.67	0.35	0.23
Impervious Land Cover (%)	0.00	0.37	0.35	0.22	0.12

Table 7. Probable stressors to fish species that were expected to occur but were absent at sites in the Baltimore Harbor watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
104-01	Creek chub	Low dissolved oxygen
106-01	Eastern mudminnow	Urban land use
	Tessellated darter	Poor physical habitat, Urban land use
108-01	Blacknose dace	Urban land use
	Creek chub	Urban land use
	Tessellated darter	Urban land use
110-01	Least brook lamprey	Urban land use
	Rosyside dace	Urban land use
	Tessellated darter	Urban land use
113-01	Least brook lamprey	Urban land use
207-01	Cutlips minnow	Low dissolved oxygen, Urban land use
	Margined madtom	Urban land use
	Rosyside dace	Urban land use
	Swallowtail shiner	Urban land use
214-01	Margined madtom	Urban land use
	Rosyside dace	Urban land use
124-96	Blacknose dace	Acidity
	Creek chub	Acidity
114-95	Creek chub	Urban land use
	Pumpkinseed	Urban land use
	Rosyside dace	Urban land use
306-95	Margined madtom	Urban land use
115-96	Eastern mudminnow	Urban land use
	Tessellated darter	Urban land use
203-95	Eastern mudminnow	Urban land use
	Least brook lamprey	Urban land use
	Rosyside dace	Urban land use
101-96	Eastern mudminnow	Urban land use, Poor physical habitat

Table 8. Probable stressors to fish species that were expected to occur but were absent at sites in the Oxon Creek watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
101-01	Creek chubsucker	Urban land use
	Cutlips minnow	Urban land use
	Rosyside dace	Urban land use
205-01	Blacknose dace	Poor physical habitat
	Creek chub	Poor physical habitat

Table 9. Probable stressors to fish species that were expected to occur but were absent at sites in the Patuxent River Middle watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
101-01	Creek chub	Acidity
	White sucker	Acidity
	Margined madtom	Acidity
	Redbreast sunfish	Acidity
	Swallowtail shiner	Acidity
115-01	Creek chub	Acidity
121-01	Tessellated darter	Acidity

Table 10. Probable stressors to fish species that were expected to occur but were absent at sites in the Piscataway Creek watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
207-01	Cutlips minnow	Acidity
	Spottail shiner	Acidity
125-97	Blacknose dace	Poor physical habitat
	White sucker	Poor physical habitat
321-97	Silverjaw minnow	Acidity

Table 11. Probable stressors to fish species that were expected to occur but were absent at sites in the Western Branch watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
107-01	Sea lamprey	Low dissolved oxygen
201-01	Pirate perch	Urban land use
	Tadpole madtom	Urban land use
212-01	Margined madtom	Urban land use
	Pirate perch	Urban land use
	Sea lamprey	Urban land use
	Tadpole madtom	Urban land use
213-97	Pirate perch	Urban land use
	Tadpole madtom	Urban land use
305-97	Margined madtom	Urban land use
	Pirate perch	Urban land use
	Sea lamprey	Urban land use
	Tadpole madtom	Urban land use
212-97	Pirate perch	Urban land use
	Sea lamprey	Urban land use
	Tadpole madtom	Urban land use
113-97	Creek chub	Bank erosion
135-97	Bluespotted sunfish	Urban land use
	Redfin pickerel	Urban land use

Table 12. Probable stressors to fish species that were expected to occur but were absent at sites in the Upper Pocomoke River watershed (where stressors were identified).

Site	*Species*	*Potential Stressor*
107-01	Banded sunfish	Riffle embeddedness
208-97	Tessellated darter	Temperature
107-97	Pumpkinseed	Acidity, Poor physical habitat

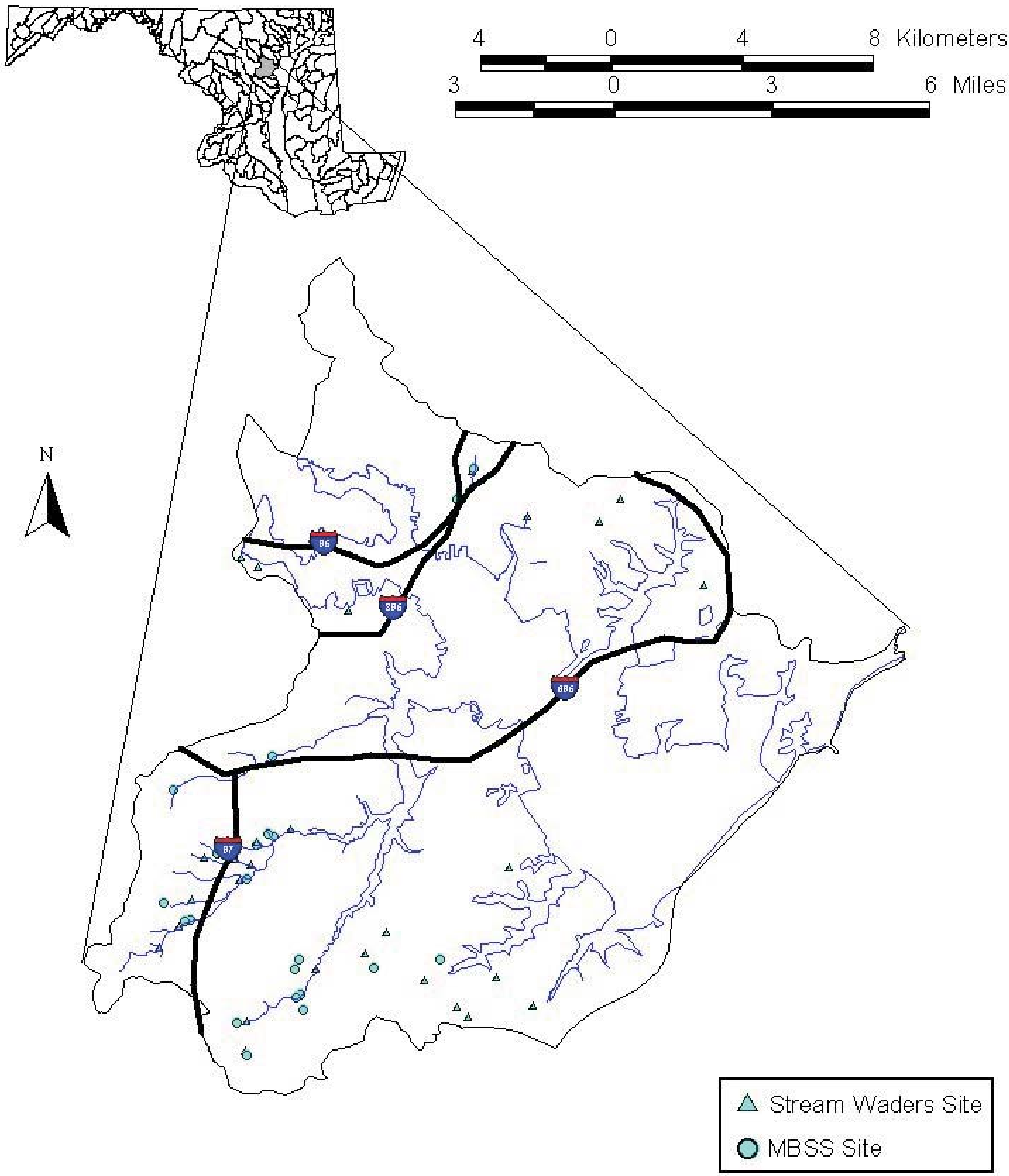


Figure 1. Sites sampled in Baltimore Harbor watershed from 1995 to 2001.

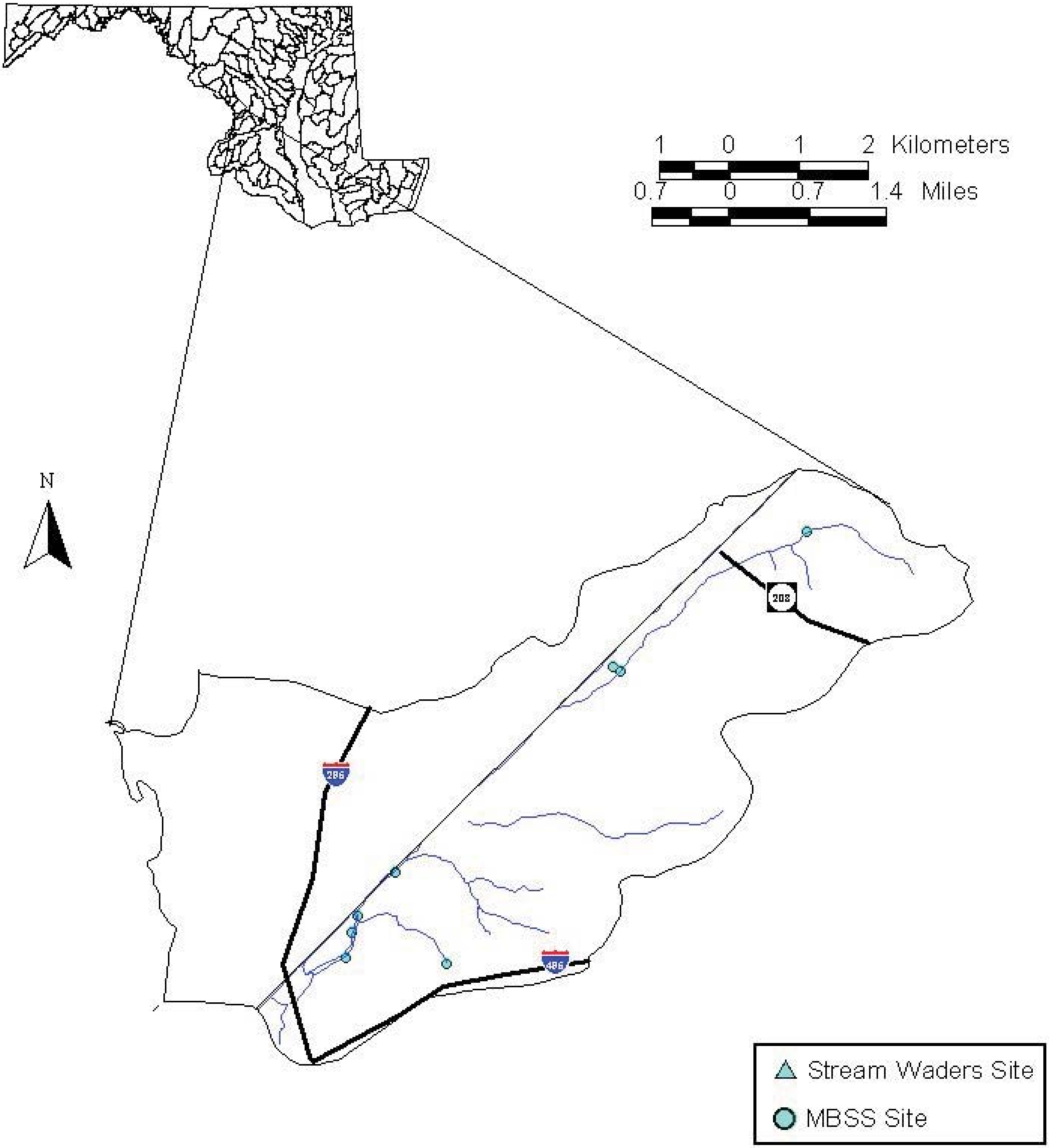


Figure 2. Sites sampled in Oxon Creek watershed from 1994 to 2001.

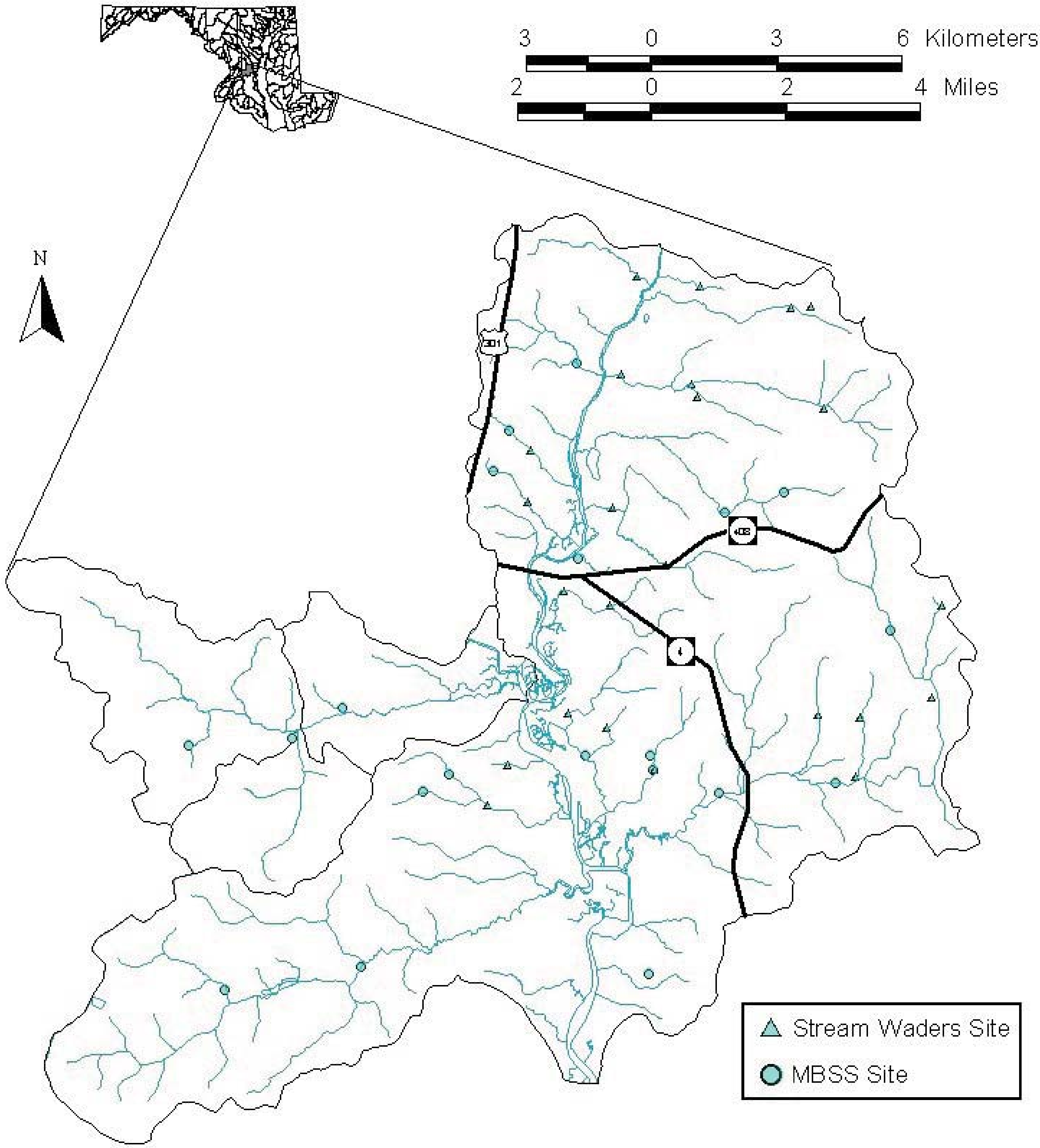


Figure 3. Sites sampled in Patuxent River Middle watershed from 1997 to 2001.

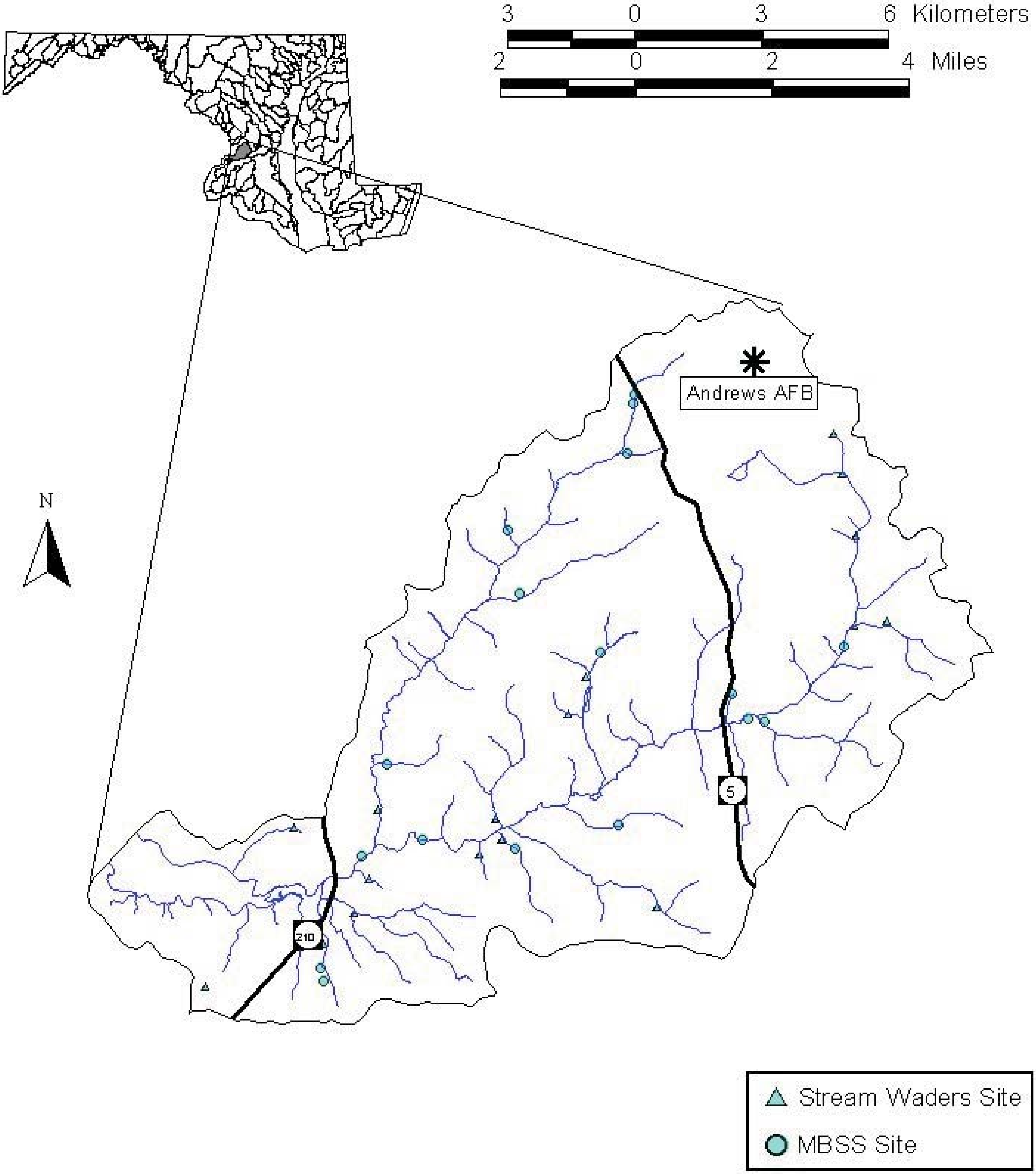


Figure 4. Sites sampled in Piscataway Creek watershed from 1994 to 2001.

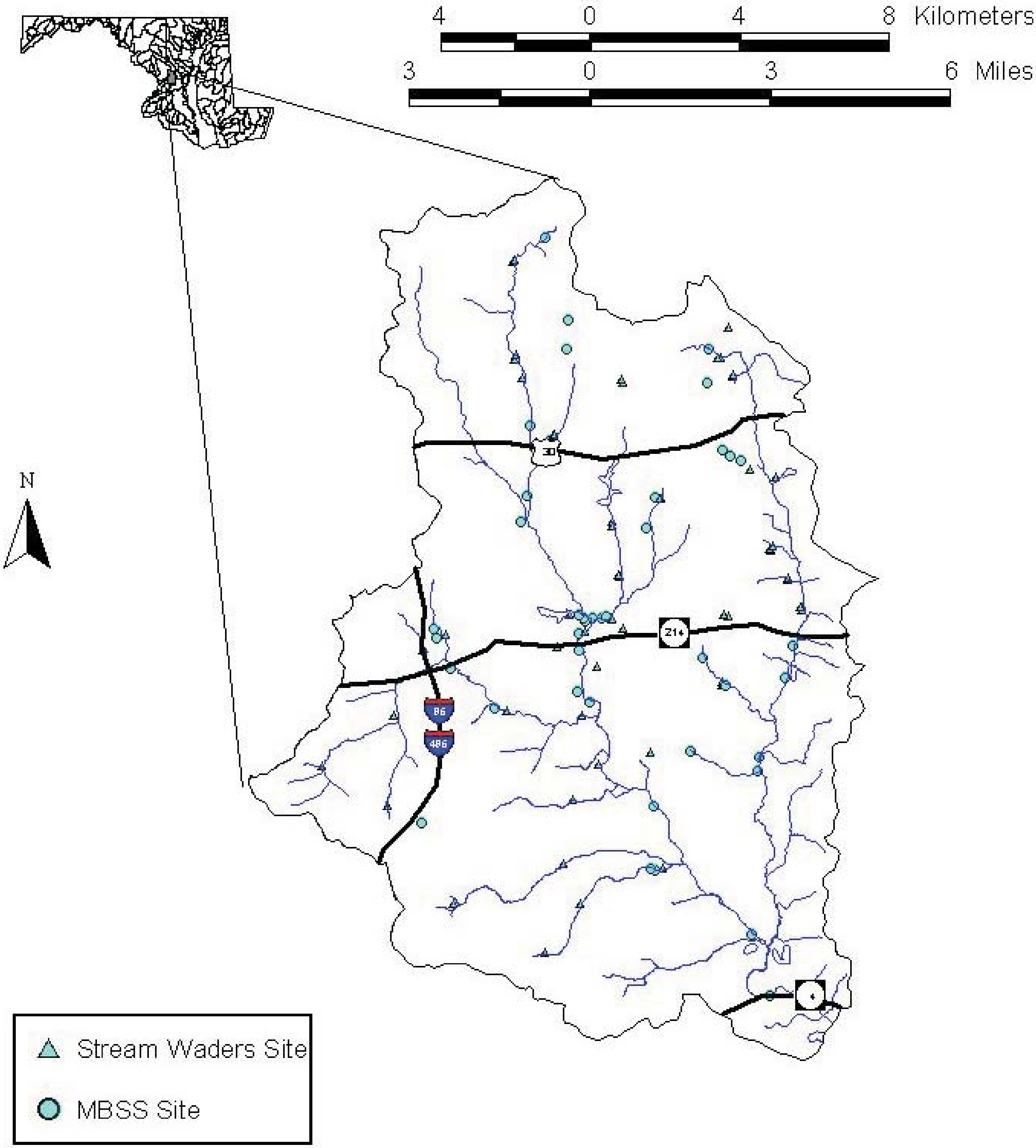


Figure 5. Sites sampled in Western Branch watershed from 1994 to 2001.

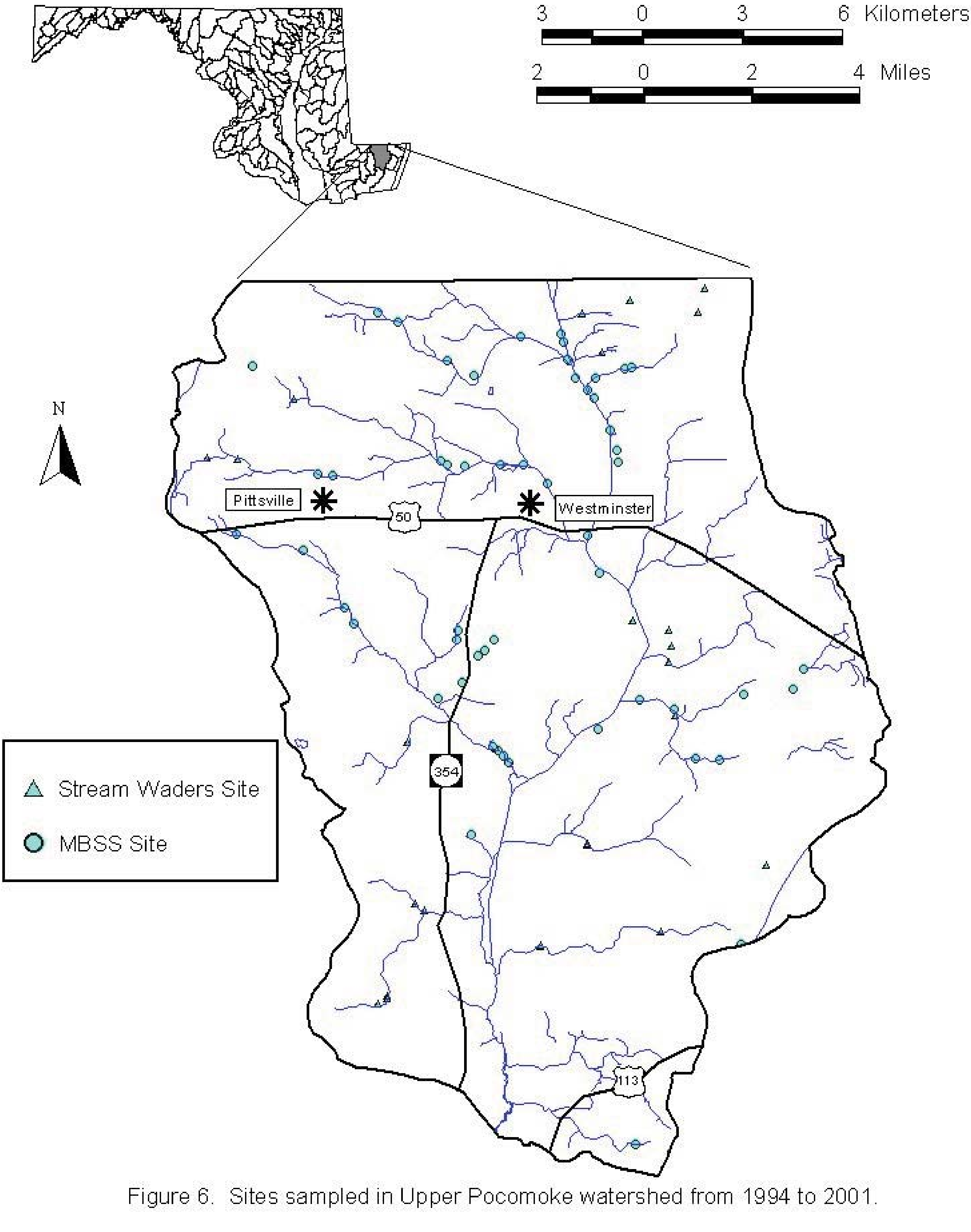


Figure 6. Sites sampled in Upper Pocomoke watershed from 1994 to 2001.

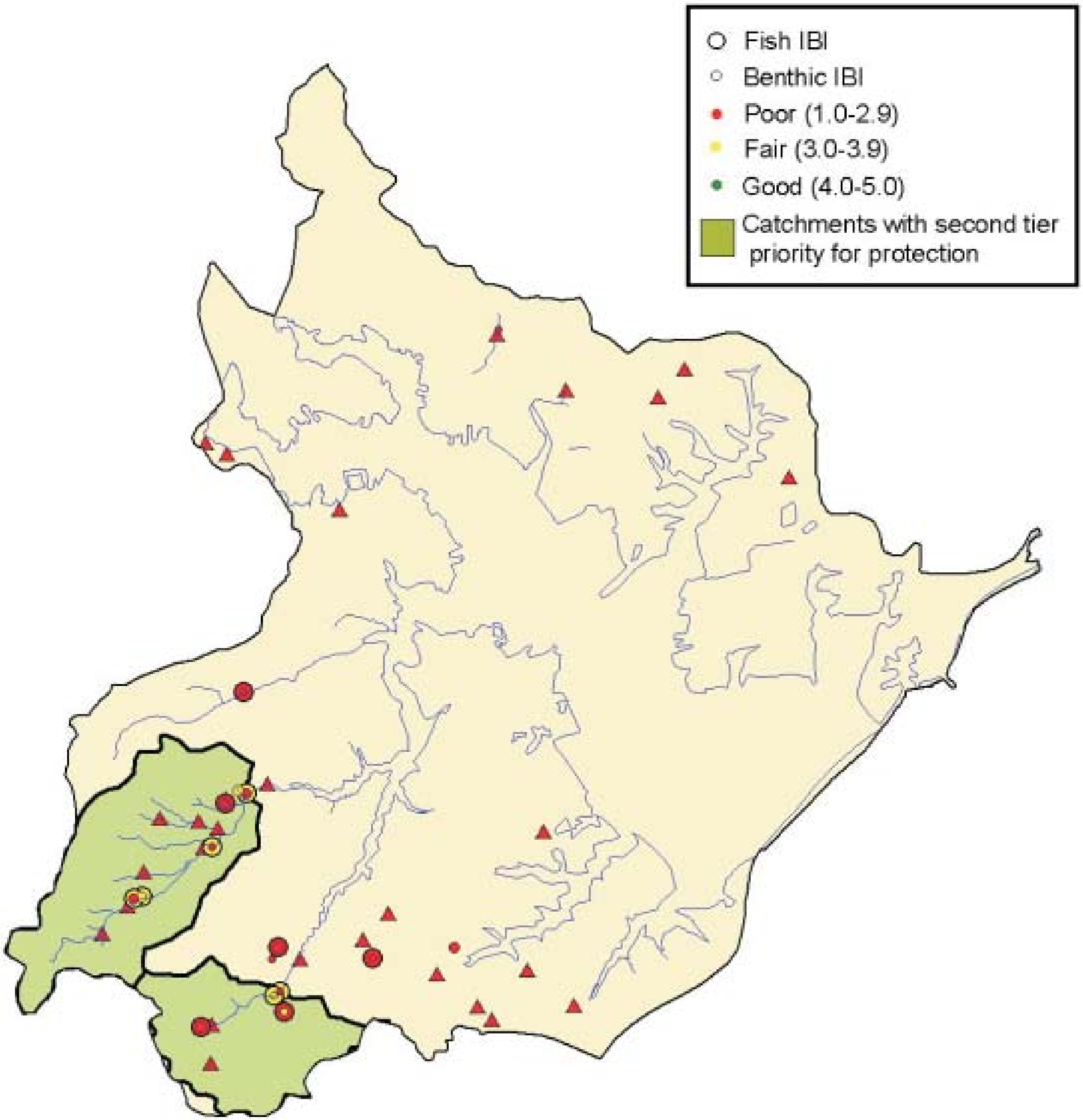


Figure 7. Areas in Baltimore Harbor watershed recommended for protection.

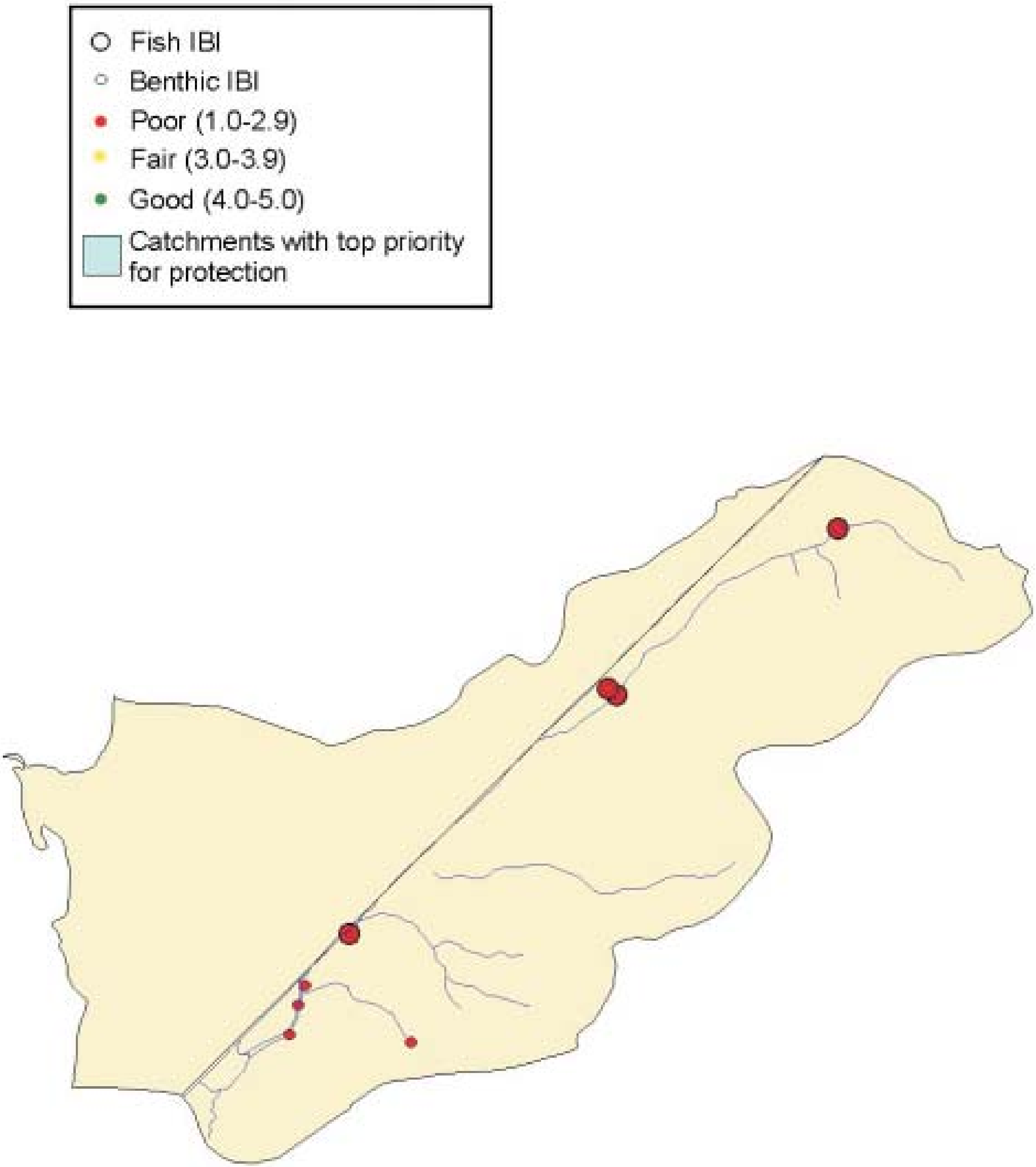


Figure 8. Areas in Oxon Creek watershed recommended for protection.

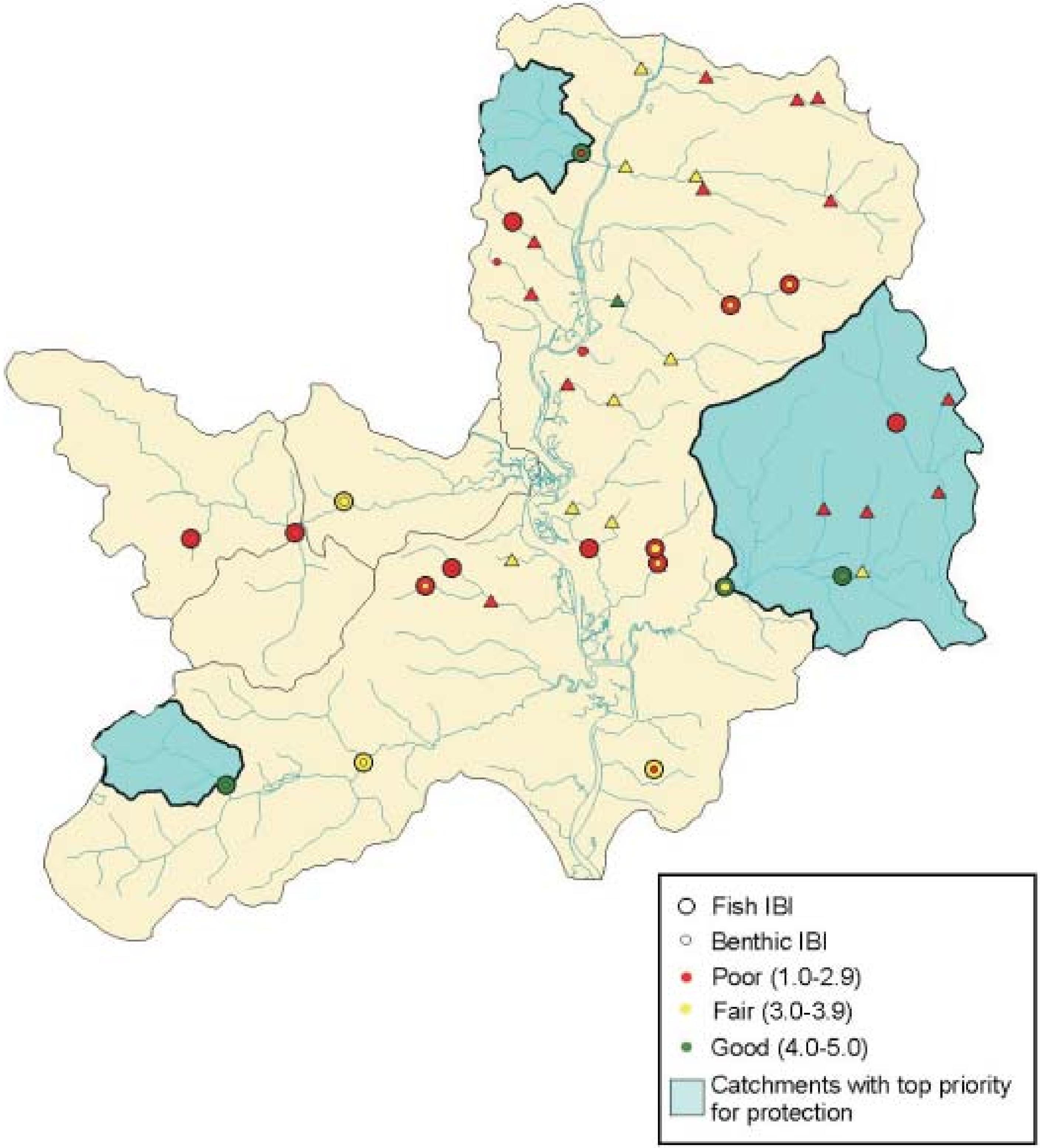


Figure 9. Areas in Patuxent River Middle watershed recommended for protection.

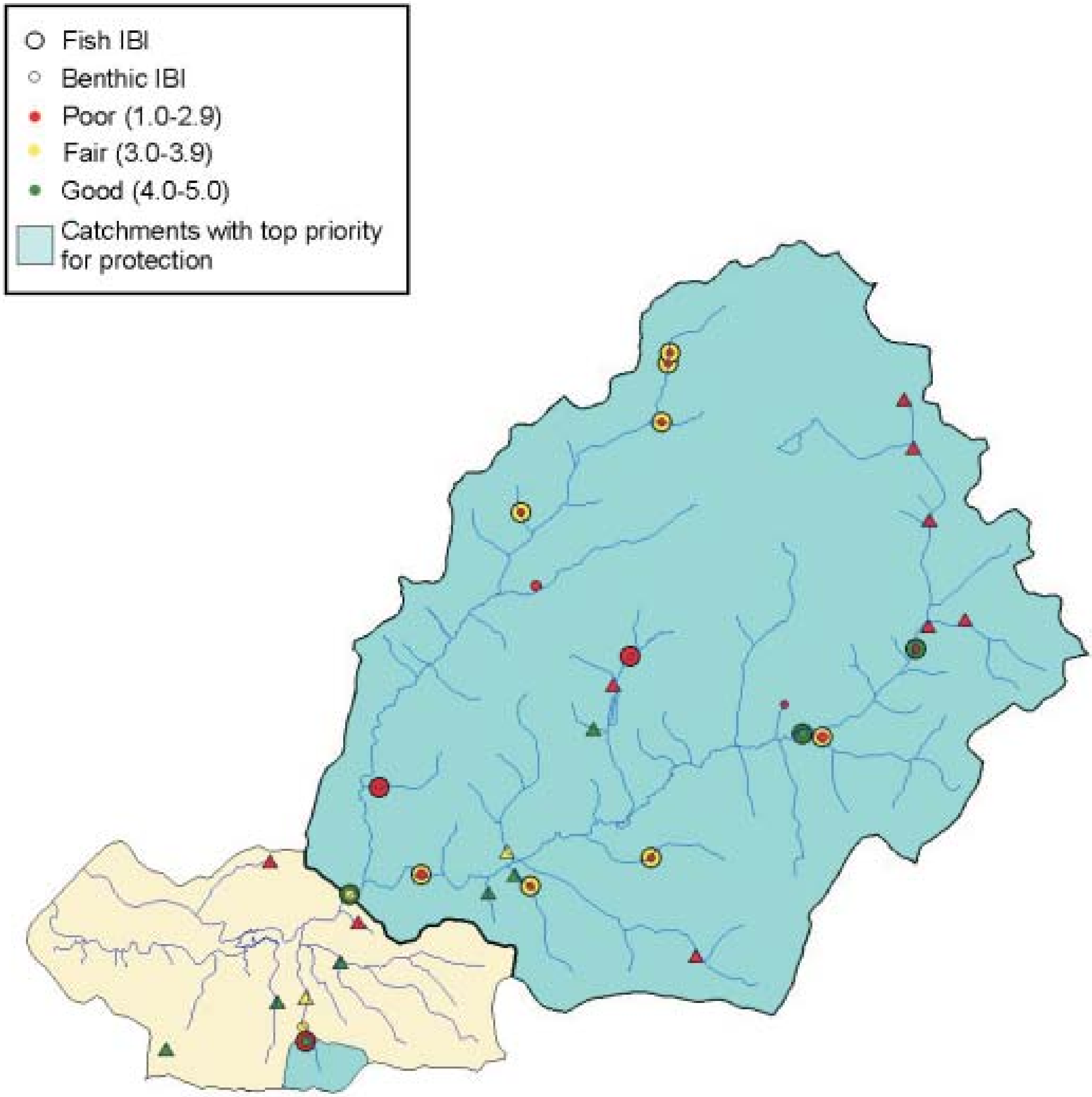


Figure 10. Areas in Piscataway Creek watershed recommended for protection.

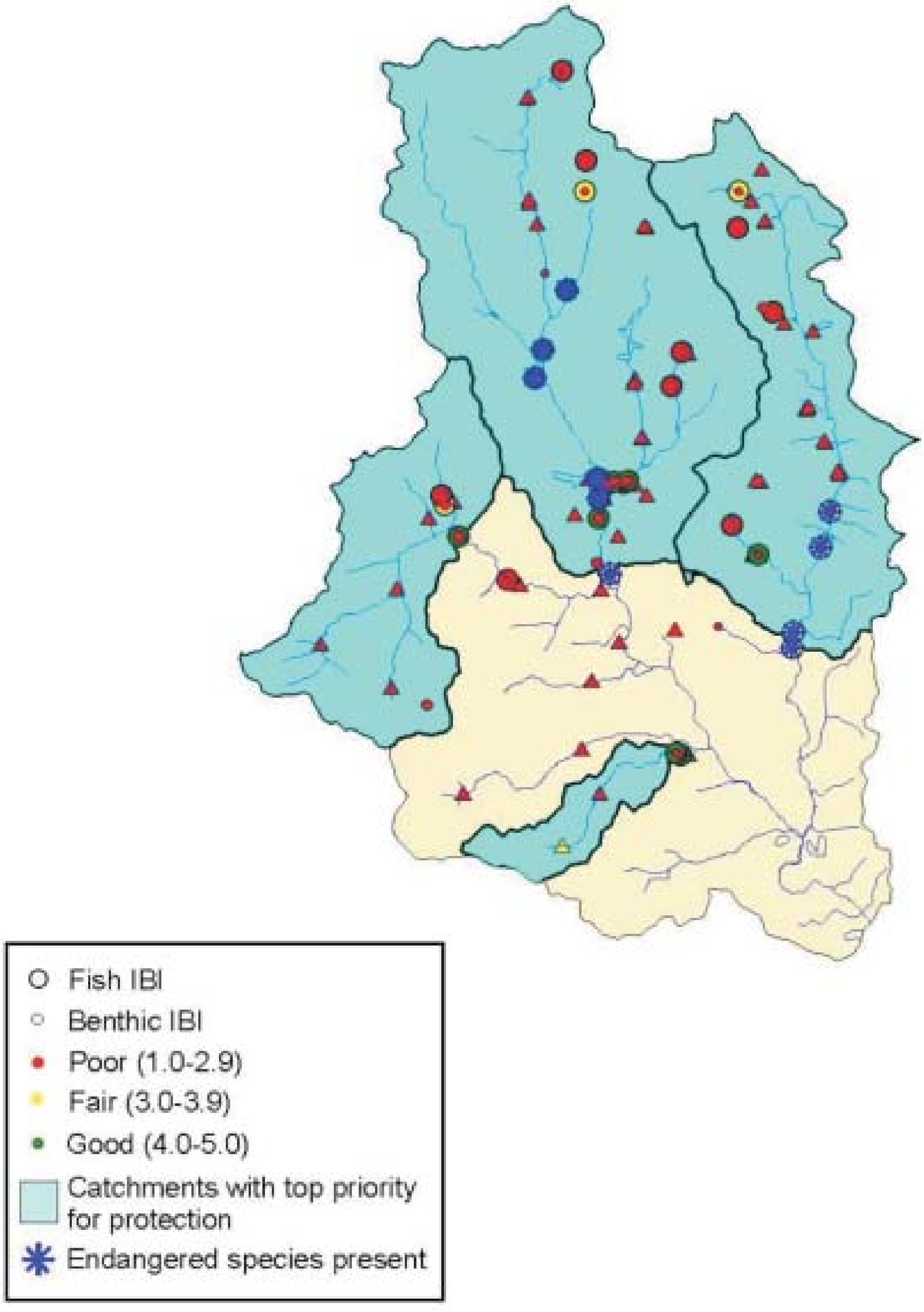


Figure 11. Areas in Western Branch watershed recommended for protection.

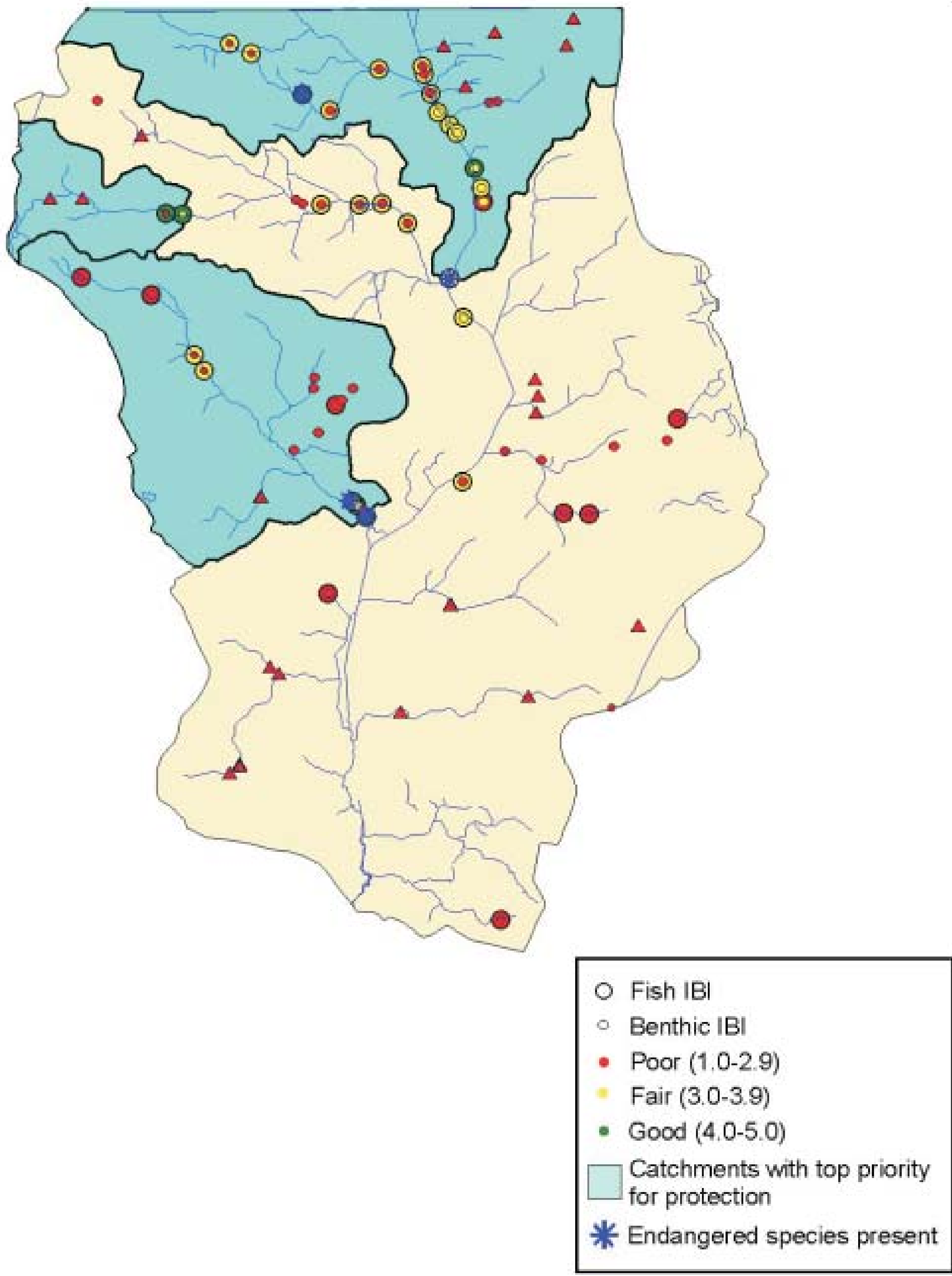


Figure 12. Areas in Upper Pocomoke River watershed recommended for protection.

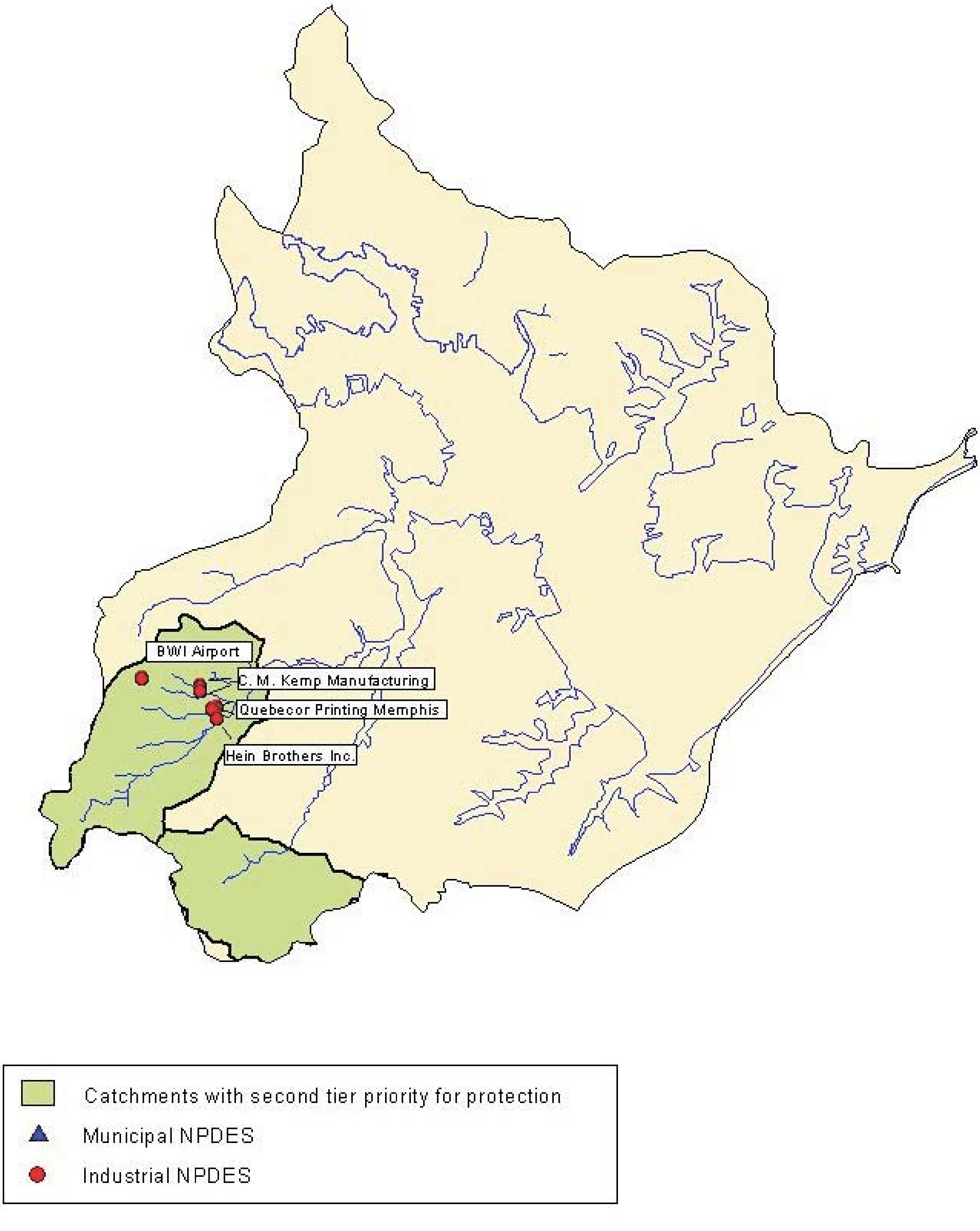


Figure 13. Municipal and Industrial NPDES sites in the Baltimore Harbor watershed.

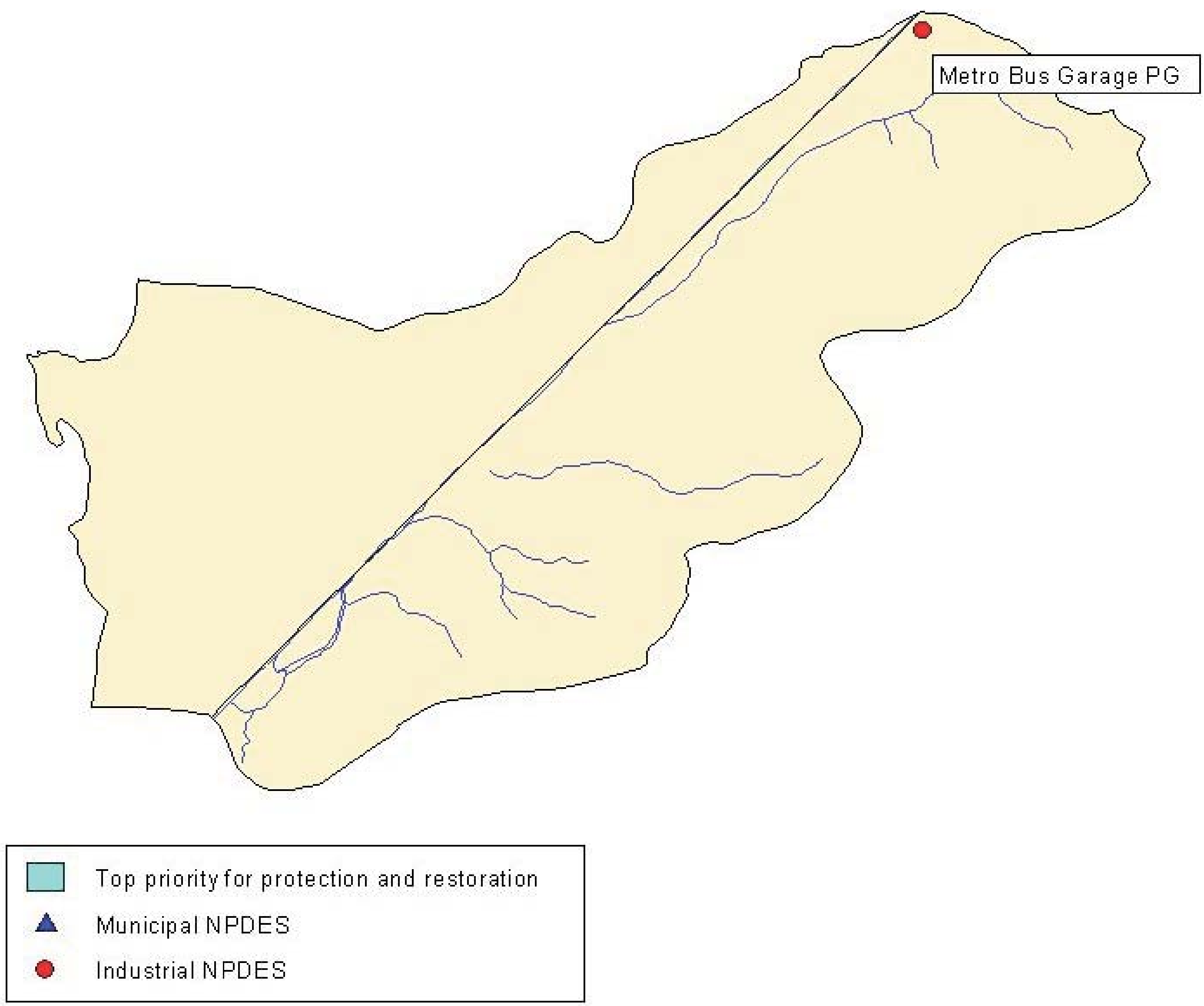


Figure 14. Municipal and Industrial NPDES sites in the Oxon Creek watershed.

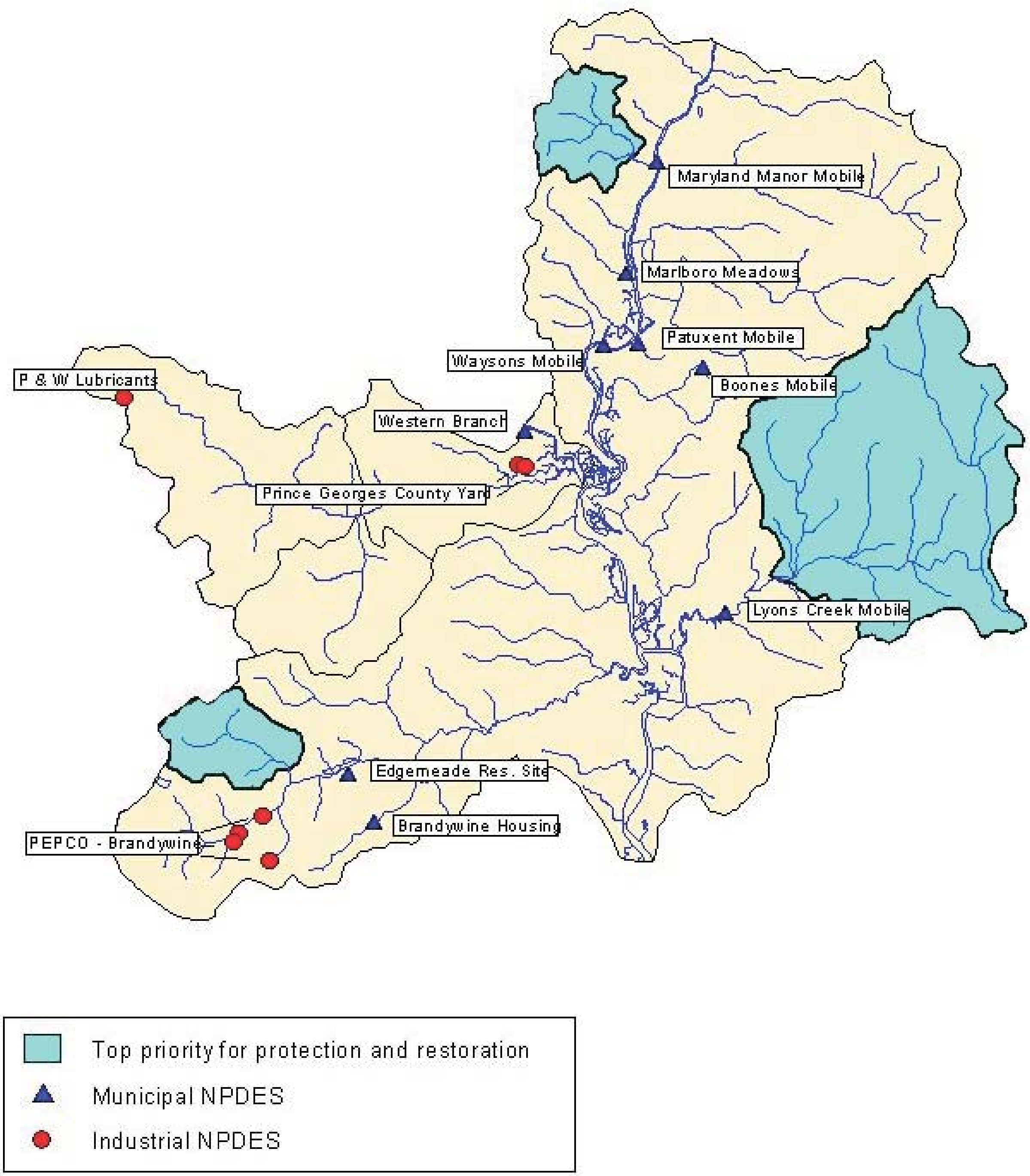


Figure 15. Municipal and Industrial NPDES sites in the Patuxent River Middle watershed.

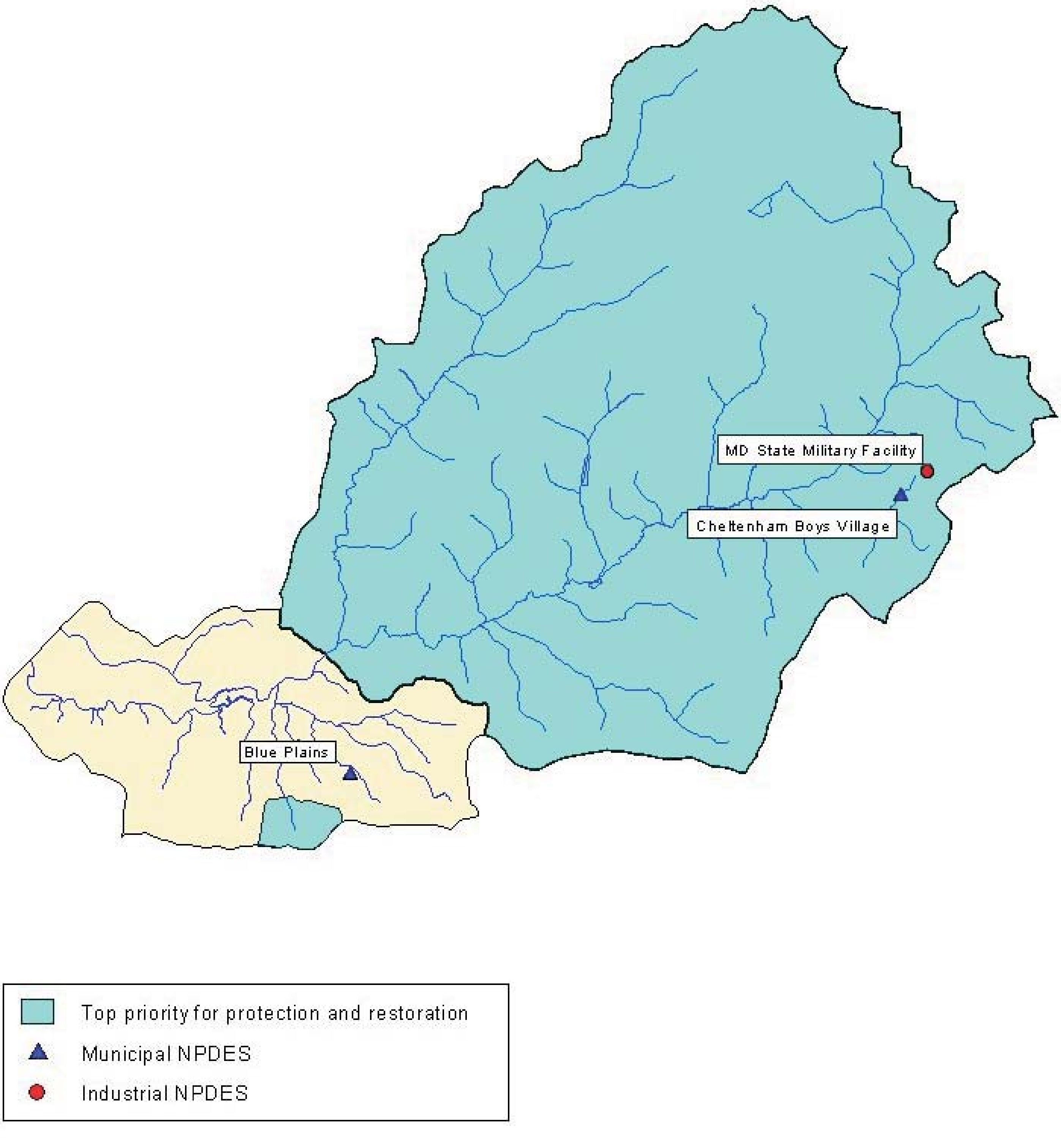


Figure 16. Municipal and Industrial NPDES sites in the Piscataway Creek watershed.

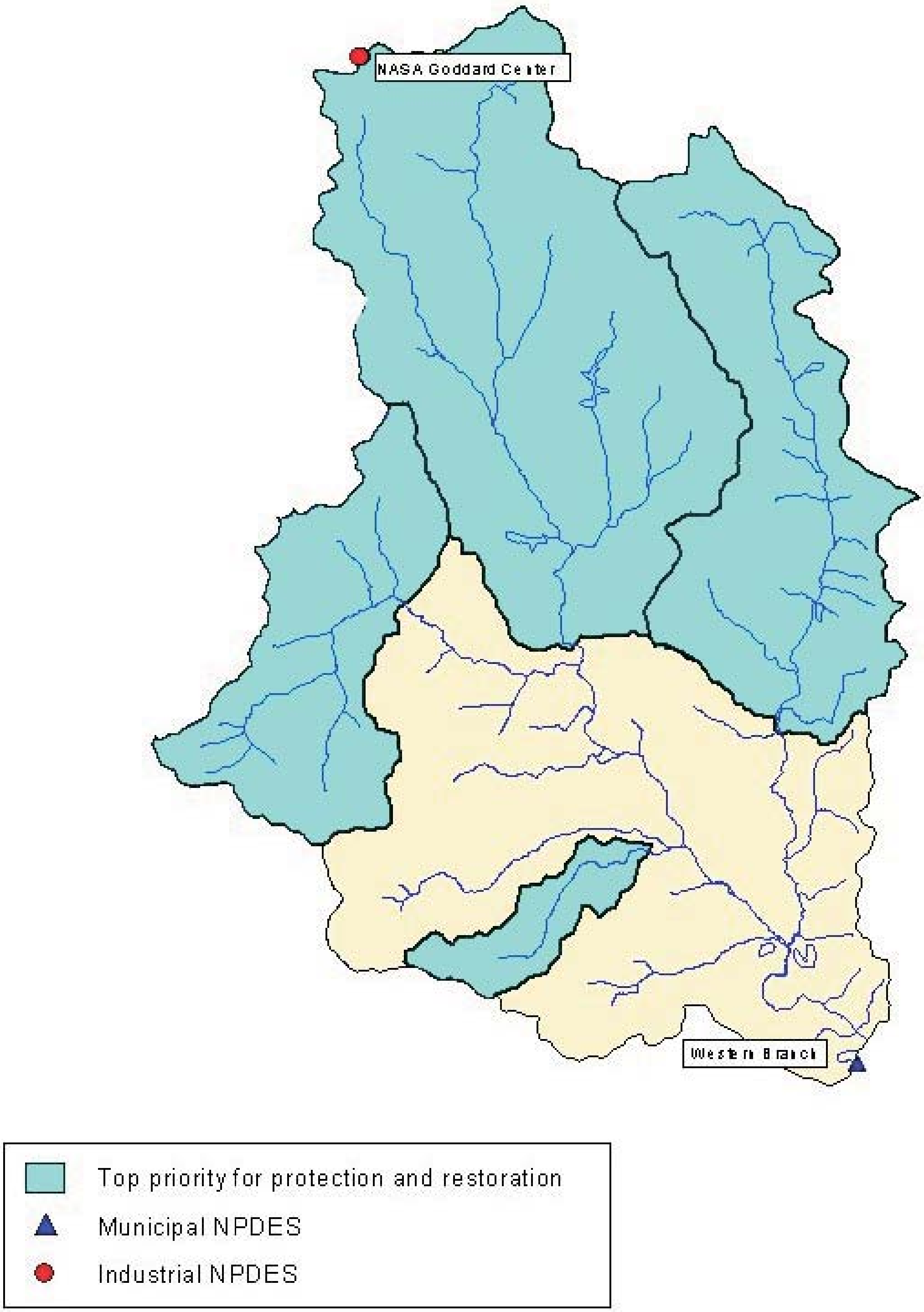


Figure 17. Municipal and Industrial NPDES sites in the Western Branch watershed.

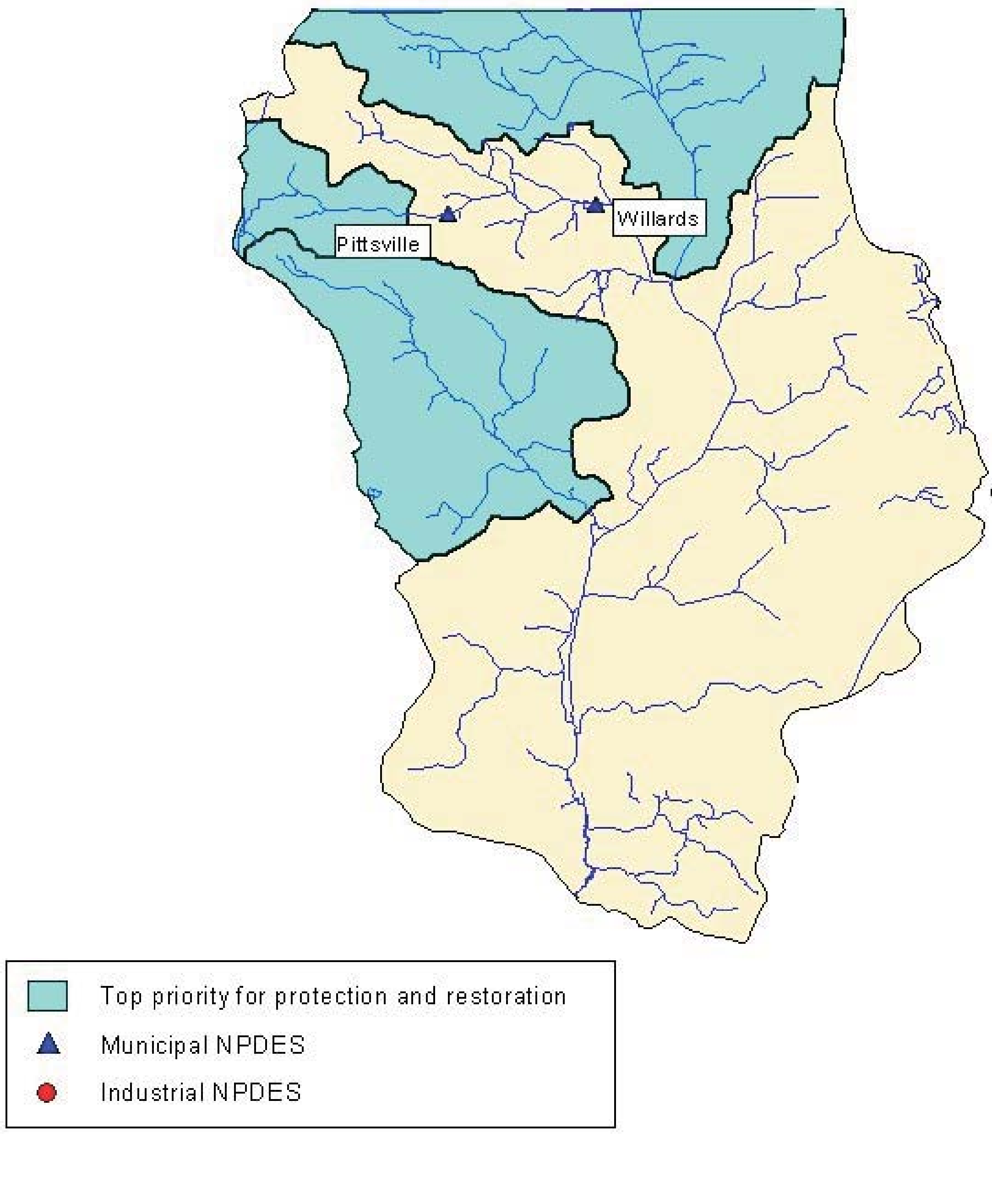


Figure 18. Municipal and Industrial NPDES sites in the Upper Pocomoke watershed.

Appendix A: Thresholds for classifying physical habitat, chemical, biological, and land use values as indicative of degradation or good quality, rare, or unique stream resources.

Biological Parameters

Fish IBI Score: Fish Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-4.9	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10^{th} to 50^{th} percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if FIBI score is <3.0.
Site is outlined in bold if FIBI score is >4.0.

Benthic IBI Score: Benthic Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-4.9	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10^{th} to 50^{th} percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if BIBI score is <3.0.
Site is outlined in bold if BIBI score is >4.0.

Water Quality Parameters

NO_3 Nitrate Nitrogen (mg/L): Site is shaded if value is >10 mg/L, and outlined in bold if value is < 1.0 mg/L.

D.O. Dissolved Oxygen (mg/L): Site is shaded if value is ≤ 5 mg/L water criterion (COMAR 26.08.02).

pH (units): Site is shaded if value is ≤ 5.0. pH less than 5.0 is considered harmful to stream biota, especially fish (COMAR 26.08.02).

SO_4 Sulfate (mg/L): Site is shaded if value is ≥ 50 mg/L.

Temperature (°C): Site is shaded if value exceeds the temperature criteria for Use Class I waters (32°C). All streams in the watersheds discussed in this report are Use Class I.

Turbidity (NTUs): Site is shaded if value is ≥ 10 NTUs.

Physical Habitat Parameters:

Physical habitat variables include the following:

Instream Habitat: Scored based on the value of instream habitat available to the fish community.

Epifaunal Substrate: Scored based on the amount and variety of hard, stable substrates used by benthic macroinvertebrates.

Velocity/Depth Diversity: Scored based on the variety of velocity/depth regimes present at a site.

Pool/Glide/Eddy Quality: Scored based on the variety and complexity of slow or still water habitat present at a site.

Bank Stability: Scored based on the stability of stream banks and potential for erosion at a site.

Site is shaded if a score for any physical habitat variable is ≤ 6, and outlined in bold if the score is > 16.

Eroded Bank Area (m^2): Site is shaded if value is > 75 meters. Site is and outlined in bold if value = 0 meters.

Erosion Severity Score: Severity of erosion on both stream banks. Site is shaded if value is ≥ 2.5, and outlined in bold if value is 0.

Embeddedness: Site is shaded in if value is 100 percent and outlined in bold if value is 0 percent.

Land Use Parameters

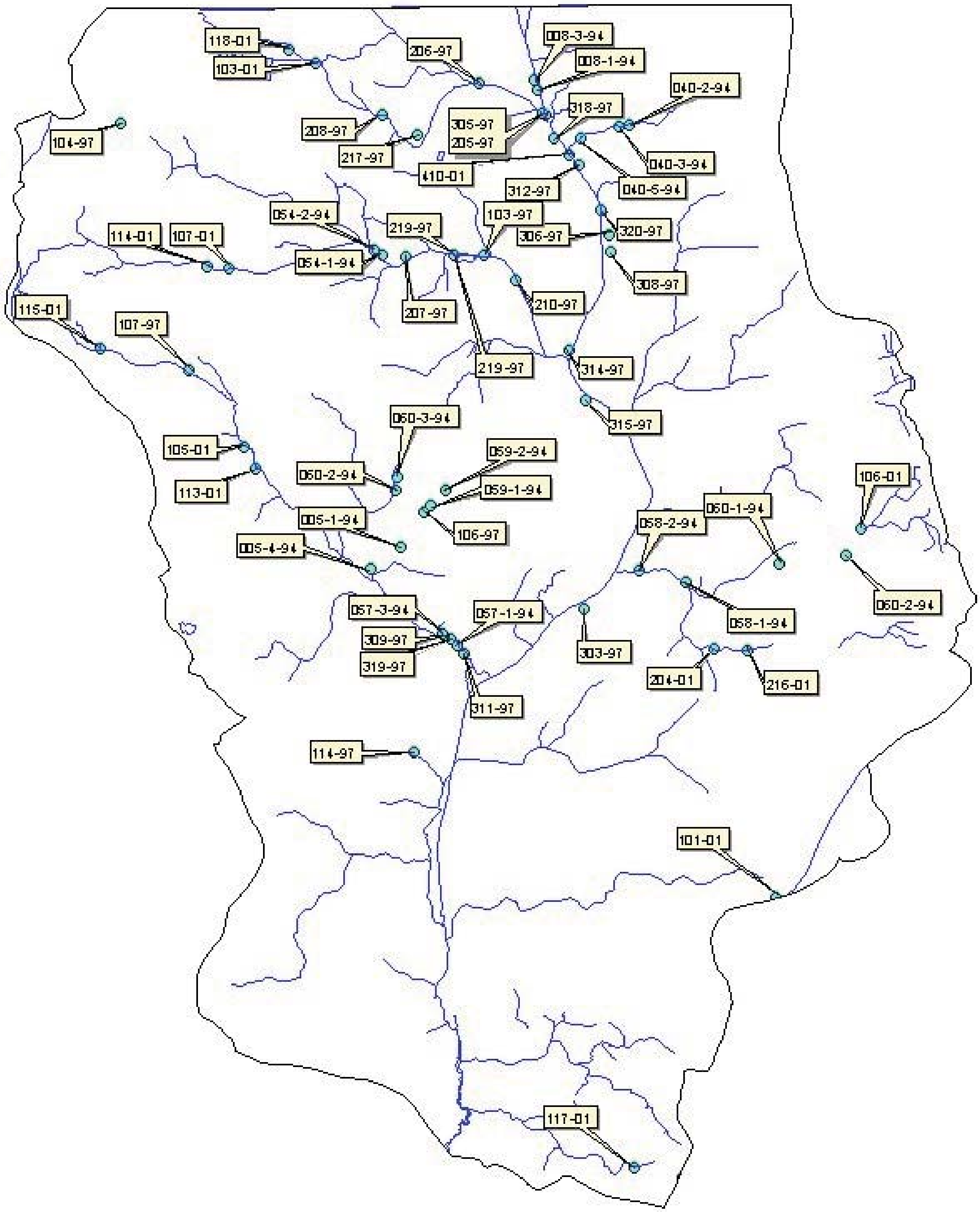
Riparian Buffer Width: Site is shaded if buffer width is <10 meters and outlined in bold if width is ≥50 meters.

Agricultural Land Use: Site is shaded if value is ≥ 75 percent.

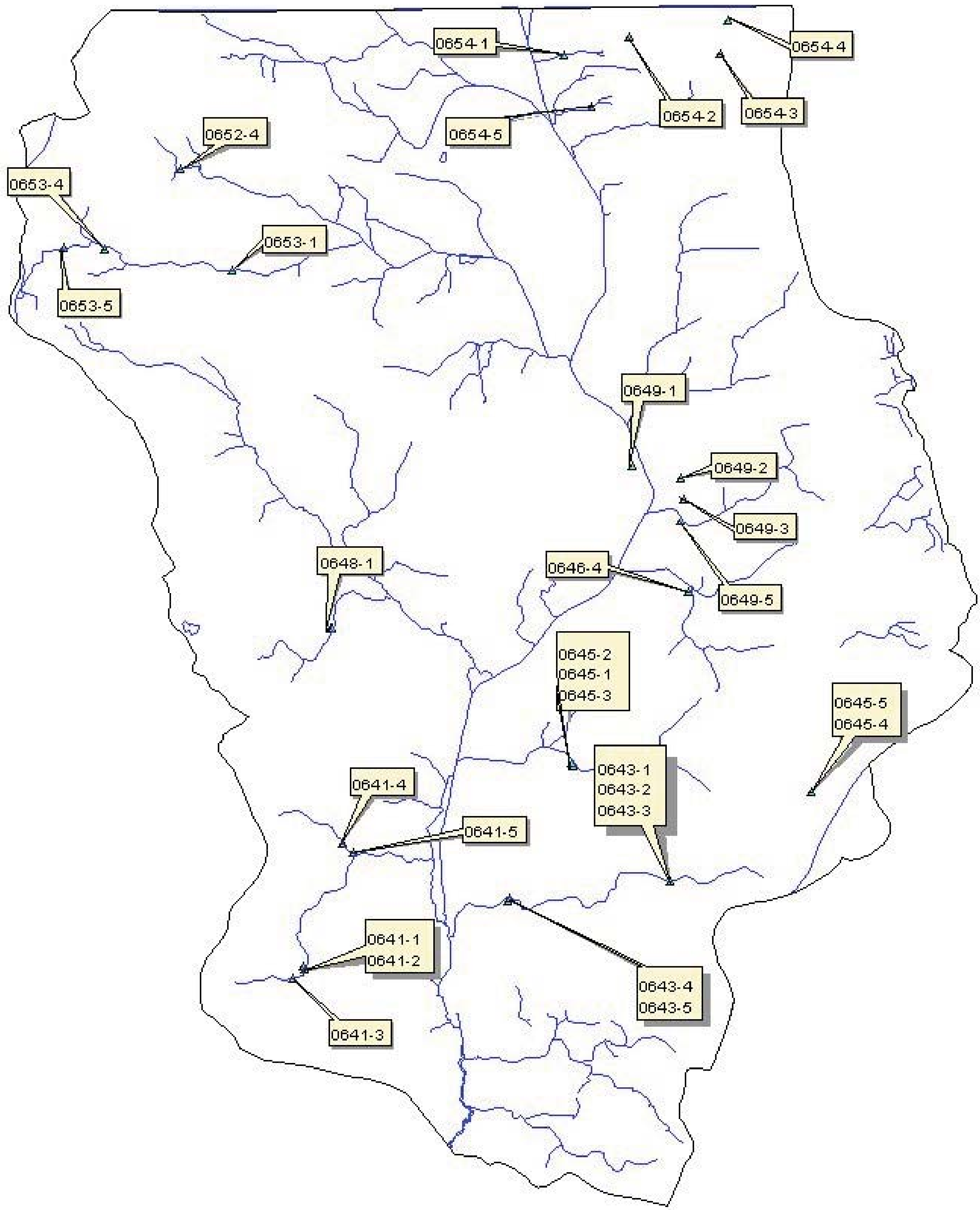
Urban Land Use (%): Site is shaded if value is > 50 percent and outlined in bold if value is ≤ 20 percent.

Impervious Land Cover: Site is shaded if value is > 10 percent, and outlined in bold if value is < 2 percent.

Appendix B
Locations of Stream Waders and Maryland Biological Stream Survey Sites



MBSS site names and locations in Upper Pocomoke watershed
sampled in 1994, 1997, and 2001.



Stream Waders site names and locations in Upper Pocomoke watershed sampled in 2001.